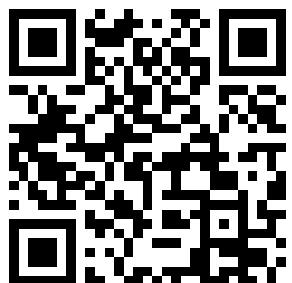


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A N  
I N Q U I R Y  
INTO THE  
ORIGINAL STATE AND FORMATION  
OF THE  
E A R T H.







*Published by Will:m Bentz, Jan: 2: 1786.*

AN  
INQUIRY  
INTO THE  
ORIGINAL STATE AND FORMATION  
OF THE  
EARTH;  
DEDUCED FROM FACTS AND THE LAWS OF NATURE.

THE SECOND EDITION,  
CONSIDERABLY ENLARGED, AND ILLUSTRATED WITH PLATES.  
BY JOHN WHITEHURST, F. R. S.

LONDON:

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## P R E F A C E.

FTER so many volumes have been written to investigate the original state and formation of the earth, and the revolutions it has undergone at sundry periods of time, it may appear presumptuous to offer my sentiments to the Public on so difficult and extensive a subject.

But when it is considered that the book of Nature is open to all men, written in characters equally intelligible to all nations, and perhaps in no part of the world more so than in Derbyshire, the wonder will in some measure cease; since natural phenomena so plentifully abound therein, that little more are required than patience and assiduity to discover their tendency to unfold the subject of the ensuing pages: for amidst all the apparent confusion and disorder of the *strata*, in that mountainous country, there is nevertheless one constant invariable order in their arrangement, and of their various productions of animal, vegetable, and mineral substances, or rather the figures or impressions of the two former.

These

P R E F A C E.

These singular appearances, together with the numerous craggy rocks, cliffs, mountains, subterraneous caverns, and many other phenomena being constantly presented to my observation, excited my attention very early in life, to inquire into the various causes of them ; not altogether with a view to investigate the formation of the earth, but in part to obtain such a competent knowledge of subterraneous geography, as might become subservient to the purposes of human life, by leading mankind to the discovery of many valuable substances which lie concealed in the lower regions of the earth.

Such were the motives which prompted me to engage in subterraneous researches ; and I flatter myself, that the facts I have obtained from my own observations, and collected from many experienced miners, may entitle the following pages to a serious and candid examination.

The several theories of the earth already produced, contain indeed many important truths, yet it must be owned that they are in general too hypothetical for an age which only admits of deductions from *facts* and the *laws of nature*.

It

P R E F A C E.

It is not however my intention to point out the faults of other systems, but to avail myself of such parts of them as are applicable to my own design, namely, *to trace appearances in nature from causes truly existent; and to inquire after those laws by which the Creator chose to form the world, not those by which he might have formed it, had he so pleased.*

To the above I have added some observations relative to Rottenstone; in which account, the place where found is omitted, namely, about two miles west of Bakewell, in lands belonging to his Grace the Duke of Rutland.

I have also taken some notice relative to the origin of the Entrochi or screw-stones, which so plentifully abound in the Derbyshire marble; being the fragments of a crustaceous marine animal, growing or adhering to rocks in the bottom of the sea, as a plant. Whence it is considered as one of the links which unites the animal and the vegetable kingdoms.

The Encrinus is likewise another species of marine animal which subsists as the former, and therefore considered as another link of the same kind. The frag-

P R E F A C E.

ments of this animal are called Asteria or star-stones, and like the former, were originally crustaceous, though now changed to a stony substance. The above animals being esteemed curious parts of natural history, a plate is given to represent their external forms.

I have also given some account of the *strata* in Flintshire, with a section and table to represent their arrangement, in order to shew their conformity to the *strata* accompanying coal in England.

I have likewise added some observations on the *strata* in the north of Ireland, particularly of the Giants Causeway, and at Balley Castle. The latter having a considerable tendency to the discovery of Coal, and the former to ascertain the origin of Basaltes.

Permit me further to add, that although the ensuing Treatise is divided into several sections, it is not to be considered as a miscellaneous work, whose parts are independent of each other, but the contrary: three of the last chapters excepted.

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AN  
I N Q U I R Y  
INTO THE  
ORIGINAL STATE AND FORMATION  
OF THE  
E A R T H.

---

C H A P. I.

*Of the Age of the World. Of the Laws of Gravity, Fluidity, and Centrifugal Force. Of the Figure and Fluidity of the Earth. Of its diurnal Rotation; Beginning; and the Mode of its first Existence.*

THE number of ages elapsed since the Deity created the constituent parts of the earth, and assembled them together by the laws of universal gravitation, seems to be one of the numerous arcanas in the great system of nature, which the sagacity of man has not hitherto been able to ascertain with any tolerable degree of precision. And probably a few more ages may yet pass away before a satisfactory solution can be given to

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that very interesting and important problem—notwithstanding the rapid progress now made in the science of natural things.

The late attempts to investigate the age of the world from natural phenomena, discovered by sinking a well in Italy, are truly ingenious. But I presume it will appear in the course of this work, that the data on which those reasonings were founded, are subject to so much fallacy, as may render the result thereof inconclusive.

Therefore, since it appears that the age of the world has not been philosophically ascertained; no physical lights can be borrowed from its great antiquity to found any reasonings upon. Hence we leave the chronological history of the earth to the decision of future ages, and for the present confine our researches to unfold its original state and formation, and the revolutions and changes it may have undergone at sundry periods of time.

The several theories of the earth produced near a century ago, contain indeed many *important truths*. Yet it must be owned that the state of physical science at those particular æras, necessarily rendered all such learned attempts, too hypothetical for the present age, which only admits of deductions from facts and the laws of nature: for having no permanent basis to found their inquiries upon, every one thought himself at liberty

ty to model the earth according to the dictates of his own imagination.

Whence arose as great a variety of theoretical systems as of writers, so contrary and discordant to each other, that the sciences of *Astronomy*, *Geography*, and *Navigation*, were greatly embarrassed thereby, and became every day more and more enveloped in obscurity and darkness.

Such was the deplorable state of those sciences till the clouds of darkness were happily removed by the sagacity of the immortal Newton; who by his superior knowledge of natural science, truly ascertained the magnitude and figure of the earth from the laws of gravity, fluidity, and centrifugal force.

That truly illustrious philosopher, not pretending to be wise above what is written in nature, did not presume to invent laws for the government of the world, but patiently sought after those which really existed in nature: being rather content with a little true knowledge, than by assuming to know much, run the hazard of error.

Thus he seems to have been led on step by step, aided by geometrical science, till he had truly demonstrated the *figure* and *magnitude* of the *earth*. Whence it appears that the equatorial diameter of the earth exceeds

the polar diameter, upwards of thirty four miles, or in the ratio of 230 to 229.

Upon that great and important truth the subject of the following inquiry into the original state and formation of the earth is founded, and perhaps it is the only one yet discovered whence it could have been derived.

Hence all attempts to investigate the subject, prior to that æra, were rendered chimerical, or without any foundation in the nature of things.

For although the facts are innumerable, which may serve to illustrate the original state and formation of the earth ; yet its oblate spheroidal figure, and its agreement with the laws of gravity, fluidity, and centrifugal force, are perhaps the only data on which the subject can be founded, and the only test whereby its truth can be examined.

But although the earth's oblate spheroidal form is an object of so much importance in many branches of science, and particularly in tracing the history of its formation ; yet so powerful did the influence of prejudice operate on the minds of cotemporary philosophers in favour of pre-conceived opinions, that the doctrines he advanced remained totally neglected many years after his decease, though founded upon the unalterable laws of nature.

However it must be owned, to the immortal honour of the French nation, that the Royal Academy of Sciences, ever

ever anxious for the improvement of science, took the matter into consideration, and represented to their Sovereign the great necessity of determining the figure and magnitude of the earth, by an actual mensuration of a degree on the meridian near the equator, and also in the polar regions, in order to ascertain the different curvatures, and from their equalities or inequalities to determine the magnitude and of figure the earth.

This princely and hazardous enterprize was undertaken in Lapland, by command of Lewis XV. and executed by Messrs. Maupertuis, Camus, Clairaut, and Le Monier, members of the Royal Academy of Sciences in the years 1736, and 1737: and in a few years afterwards the equatorial mensurations were completed by command of the King of Spain, by Don George Juan, Don Antonia Ulloa, M. Condamine, &c. The result of the several mensurations were as follows, viz.

The earth's equatorial diameter = 7940,598 } English miles.  
The polar diameter = - - 7903,650 }

Whence it appears that the earth's equatorial diameter exceeds its polar diameter  $36\frac{9}{100}$  miles: a proportion which so nearly coincides with the result of Sir Isaac's demonstration, deduced from the laws of gravity, fluidity, and centrifugal force, that the magnitude and figure of the earth were hence forward considered as determined with

with sufficient accuracy for the various purposes of astronomy, geography, navigation, and natural history.

Let it be remembered that Mr. G. Graham, our celebrated countryman, was principally concerned in constructing the apparatus employed in surveying the polar regions.

Having premised these matters, it may be convenient to observe, that in order to render the subsequent reasonings familiar to those who have not previously considered the laws of gravity, fluidity, and centrifugal force, on which the subject altogether depends ; I have therefore endeavoured to adopt such propositions for that purpose alone as may serve to render the work more universally intelligible : and therefore, as the subject concerns the generality of mankind, I hope my learned philosophic readers will pardon the steps I have taken to obtain that desirable end ; since without such precaution the work must have been altogether unintelligible to them.

#### PROPOSITION I.

According to the universal law of gravitation, the constituent parts of all bodies mutually attract each other : whence arise their common centers of gravity ; which so govern their component parts, as to cause all such as are fluid, and do not revolve round their own axes, to assume spherical forms.

*Example*

*Example I.*

If two equal particles of matter mutually attract each other at any given distance, as at A and B, *Fig. 1.* fig. 1. they will consequently move with equal velocities towards each other, in the direction A C, and B C, and come into contact at the mean distance C: therefore the point C may be considered as their common center of gravity.

*Example II.*

If three equal particles of matter mutually attract each other at A B D, *Fig. 2.* fig. 2. they will also move towards each other with equal velocities, in the direction A C, B C, D C, and come into contact at the mean distance C: therefore the point C may truly be considered as their common center of gravity.

*Example III.*

If four equal particles of matter mutually attract each other at A B D E, *Fig. 3.* fig. 3. they will likewise move with equal velocities in the several directions A C, B C, D C, E C, and consequently come into contact at the mean distance C: therefore the point C may be considered as their common center of gravity.

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These few examples may serve to shew, that an infinite number of particles may be thus assembled together in every possible direction, and thereby constitute a common center of gravity. Hence it evidently follows that the center of gravity in all bodies wholly arise from the mutual attraction of their component parts, and not from any latent attractive principle situate in the center of the body itself.

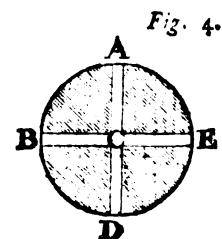
Hence the component parts of fluid bodies, being thus assembled together, necessarily assume spherical forms, as may be observed in drops, or small portions of water collected upon vegetables in the summer months, called dew; and likewise in small portions of mercury, melted metals, &c.

But to illustrate the cause of fluid bodies thus assuming spherical forms, more fully, let fig. 4. represent a globe similar to that of the earth, perforated from A to D, and from B to E; but not revolving round its axis. And let us suppose the perforations completely filled with water.

Now since the component parts of water mutually attract each other, it evidently follows, that the respective columns A C, B C, D C, E C, will have an equal tendency towards their common center of gravity C; consequently their respective lengths will be equal: and there-

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fore if an infinite number of perforations were thus made in every possible direction, and filled with water, their lengths would be equal also. Hence it is that fluid bodies which do not revolve about their axis assume spherical forms, from a mutual attraction of their component parts.

And therefore, since it appears that there are no other laws or principles in nature yet known, whence bodies assume spherical forms, the presumption is great, that all bodies naturally spherical have been originally in a state of fluidity, although they may be firm and solid in their present state.

Having thus endeavoured to define the law of universal gravitation, together with its effects on the component parts of all bodies; we have now to consider the universal laws of motion, and their effects on bodies revolving round their own axis.

#### PROPOSITION II.

According to the universal laws of motion, the constituent parts of all bodies which revolve upon their own axis, acquire centrifugal force proportional to their velocities: therefore, as their distances are to each other from their axes of motion, so are their velocities, and so are their centrifugal forces. *Newton's Princip. vol. 1, prop. 4, section 2.*

C

*Example*

*Example I.*

Let fig. 1. plate III. represent an equatorial section of a globe, or the plane of its equator, revolving with any given velocity, or performing any number of rotations in the space of *one minute, one hour, one day, or one year*. And let us suppose its radius divided into six equal parts, by means of the concentric circles 1, 2, 3, 4, 5, 6.

Now since the circumferences of all circles are to each other as their respective diameters ; it will evidently follow, that the velocity, and centrifugal force of the particles contained in each circle will increase according to the several distances from their axis, or center of motion A. Again,

*Example II.*

Let fig. 2, plate III, represent the polar section of a globe, A A its axis, and E E its equator, and let us suppose its equatorial radius divided into six equal parts, as represented by the lines 1, 2, 3, 4, 5, 6, running parallel to the axis A A. Hence it appears, according to the former diagram, that the velocity and centrifugal force of the particles contained in each line will increase according to their respective distances from their axes of motion A A.

Now since the velocity, and centrifugal force of the particles contained in the axis A A is nothing ; and that the

the velocity and centrifugal force of the particles contained in the lines 1, 2, 3, 4, 5, 6, increase according to their respective distances from their axis of motion A A, it evidently follows, that the equilibrium of gravitation is destroyed in all revolving bodies: and therefore such as turn round their axes in a state of fluidity, will necessarily depart from a spherical form, and assume that of an oblate spheriod, whose equatorial diameters will exceed their polar diameters, in a certain ratio, according to the *square of their periodical rotations.*

Such are the consequences necessarily arising from the laws of gravity, fluidity, and centrifugal force, combined: and therefore since there are no other laws or principles in nature yet known, whence bodies can naturally acquire oblate spheroidal forms; may we not thence conclude, that all oblate spheriodical bodies acquired those particular forms, by revolving round their own axes in a state of fluidity, although they may be *firm and solid in their present state.*

Therefore since it is a truth universally known, that the figure of the earth is an oblate spheroid, perfectly coinciding with the laws of gravity, fluidity, and centrifugal force; may we not thence infer that the earth acquired its oblate spheroidal form by revolving round its axis, in a state of fluidity; although it is firm and solid in its present state.

Now since the figure of the earth so perfectly coincides with the unalterable laws of nature, the presumption is great, that its diurnal rotation has not suffered any change or variation, but has performed equal rotations in equal times from the *moment of its first existence, to the present æra.*

Whence it appears highly probable, that as the diurnal revolutions of the earth have been performed in equal periods of time, in all preceding ages ; by purity of reason we may presume, that *its annual revolutions* have also been performed in *equal periods of time* ; and if so, the mensurations of time have been invariably alike from the beginning of the world to the present æra.

Having endeavoured to prove from the laws of nature, that the earth was originally in a state of *fluidity* ; and likewise that the length of days and years have been equal in all preceding ages ; let us take into consideration the cause of its fluid state ; and whether it is more probable that the earth had a beginning, or whether it has existed from eternity, as some have imagined.

It will be readily granted, that if the earth was created, it must have been brought into existence either in a solid, or in a fluid state : if we suppose the former, it must have been dissolved, and this by an universal dissolvent principle : therefore since no such principle is yet known to exist in nature, it seems much more reasonable

ble to conclude that the fluidity of the earth was owing to the first assemblage of its component parts, than to any subsequent solution.

Therefore it is more probable that the earth had a beginning, than that it has existed eternally, as some writers have supposed; though the period of its past existence has not hitherto been philosophically ascertained.

As some further testimony of the preceding conclusions with respect to the fluidity of the earth, the equability of its diurnal rotation, the commencement of its first existence, &c. it may not be improper to enumerate the following instances with respect to the planetary system.

Sir Isaac Newton has observed, Proposition 18, Theorem 16. "That the axes of the planets are less than the diameters drawn perpendicular to the axes." . . . .

"The equal gravitation of the parts on all sides, would give a spherical figure to the planets, if it were not for their diurnal revolutions in a circle. By that circular motion it comes to pass that the parts receding from their axes, endeavour to ascend about the equator; and therefore if the matter is in a fluid state, by its ascent towards the equator it will enlarge the diameter there, and by its descent towards the poles it will shorten the axes.

"So the diameter of Jupiter (by the concurring observations of astronomers) is found shorter between pole and pole, than from east to west. And by the same

"argu-

“ argument, if our earth was not higher about the equator than at the poles ; the sea would subside about the poles, and, rising about the equator, would lay all things there under water.”

And according to the observations of Mr. Herschel on the planet Mars, it appears that its equatorial diameter is greater than its polar diameter.

Such phenomena therefore, seem to shew, that all the planetary system is equally subject to the same laws of gravity, and centrifugal force with the earth ; and also that the former as well as the latter were originally in a state of fluidity, and derived their oblate spheroidal forms from the same principles.

Hence we may conclude that the fluidity of the planets was not owing to any dissolvent principle, but to the first assemblage of their component parts : whence it appears that they were also brought into existence at some remote period of time, and have not existed from all eternity, as might have been imagined.

Whether the above inferences are conclusive, or not, must be submitted to the judgment of the candid reader ; however, since we are not conscious that any part thereof is in any degree repugnant to the laws and operations of nature, we shall therefore proceed to consider the consequences arising from the fluidity of the earth, in the following chapter.

CHAP.

## C H A P. II.

*Of the chaotic State of the Earth. Of its not being habitable. Of the Antiquity of geometrical and philosophical Sciences.*

**A**CCORDING to the result of the preceding deductions, the globe which we now inhabit, was originally in a state of fluidity, owing to the first assemblage of its component parts, and the infinite divisibility of matter. Our present object therefore is to investigate the consequences necessarily arising from that particular state and condition of the earth.

The fluidity of the earth manifestly implies, that the particles of matter which now composes the strata and all other solid bodies, were not originally united, combined or fixed by cohesion, but were actually in a state of separation, as particles of sugar or salt, dissolved and suspended in water.

It is a truth universally known, that the component parts of the most dense bodies become suspended in what ever menstrua they are dissolved ; as for instance, the particles of gold in aqua regia, silver in aqua fortis, salts in water, and water in air. Nay we may likewise add, that the component parts of mercury in the act of distillation become suspended in air, notwithstanding the specific

cific gravity of the former is to that of the latter, as 11000 to 1, nearly. Such therefore are the consequences necessarily arising from the infinite divisibility of matter, none being heavier or lighter than another, when thus reduced to their original elementary principles.

Whence it appears, that when the component parts of the earth were first assembled together, they were in a state of uniform suspension, and seem to have composed one general undivided mass or pulp, of equal consistence and sameness in every part, from its surface to its center; and therefore constituted that particular state and condition of the earth, which the ancients have named chaos, and have described as a confused mass or pulp, composed of all the various elementary principles blended together, and *without form and void*.—That is to say, the chaos had not yet acquired an oblate spheroidal form, and the component parts thereof were void of that arrangement which constitutes bodies of different denominations; as *air, water, stone, minerals, &c.* but the whole mass compounded of the various elementary principles, blended together in one confused heap.

Consequently the chaotic state of the earth was totally unfit for animal or vegetable life; and therefore it would be extremely absurd, and repugnant to the laws of nature, to suppose that any such bodies were created before the chaos was become suitable to the nature of their

ex-

existence. And this idea, concerning the primitive state of the earth, not only coincides with the *Mosaic account of the creation*, but likewise with the opinions of the most ancient philosophers, historians, and poets, who have roundly asserted, but not proved the doctrines they have advanced; for, it does not appear that their opinions were the result of physical deductions, but they rather seem to have been borrowed from popular opinions which prevailed in the several ages wherein these authors lived. For instance,

“ The Phenicians believed that the earth was originally a fluid mass or pulp: and the same opinion is well known to have been so strongly impressed on the minds of the Egyptians, that one of their kings, Ptolemy, the son of Lagos, is said to have erected a temple in commemoration of it, built of all the various kinds of stones; in which was placed an altar of divers colours, and a statue of the god Serapis, composed of all the different kinds of metals mixed together, alluding to the confusion of elements.” See *Histoire de la Philosophie*, par Deslandes.

Such were the doctrines maintained by the ancients concerning the original state of the earth; but it does not appear whether the Phenicians or the Egyptians were the original authors of those tenets, or whether they were borrowed from the learning of more ancient nations.

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Thus much however we may venture to assert, namely, that since it appears that the earth in its chaotic state was not habitable ; we may thence conclude, it was not inhabited : and therefore such opinions could not have been originally derived from observation. Whence it necessarily follows that such doctrines were originally the result either of revelation, or of reason. Now if from the former, all physical inquiry ceases, but if from the latter, or from philosophical deductions, may we not thence conclude, that such opinions were originally derived from the laws of gravity, fluidity, and centrifugal force ; since there are no other principles in nature yet known, from whence such ideas could have been fully and truly obtained, though there are many corroborating testimonies which evidently shew, that the earth was originally in a state of fluidity ; and therefore the presumption is great, that the Newtonian philosophy was familiarly known in remote antiquity, possibly much anterior to the Phenician or Egyptian nations, though totally lost and afterwards revived again by Sir Isaac Newton.

Hence we consider the opinions of the ancients concerning the chaotic state of the earth, as the scraps or fragments of ancient learning.

It is a common observation, that arts ever expire with ruined empires, conquered by savage barbarians. And

we have likewise some instances upon record of great revolutions arising from natural causes, in the early ages of the world; namely by *subterraneus convulsions*, *deluges*, &c. whereby the succeeding race of people were deprived of the advantage arising from the preceding state of arts, as much as if no such arts had ever existed.

The observations of Lord Bacon seems to corroborate the preceding ideas, relative to the antiquity of science. In his preface on the Wisdom of the Ancients, he writes thus :

“ Above all things this prevails most with me, and is  
“ of singular moment; many of these fables do not seem  
“ to have been invented by the authors by whom they  
“ are related and celebrated, as Homer, Hesiod, and  
“ others; for if it were so, that they took beginning in  
“ that age, and by those authors by whom they are de-  
“ livered and brought to our hands, I imagine there  
“ could be no great or high matter expected, or sup-  
“ posed to proceed from them, in respect to those origi-  
“ nals. But if with attention we consider the matter,  
“ it will appear that they were delivered and related as  
“ things formerly believed and received, and not as new-  
“ ly invented, and offered to us. Besides, seeing they  
“ are diversly related by writers that lived nearly about  
“ one and the same time, we may easily perceive that

“ they were common things, derived from precedent  
“ memorials ; and that they became various by reason of  
“ the divers ornaments bestowed on them by particular  
“ relations. And the consideration of this must needs  
“ increase in us a great opinion of them, as not being  
“ accounted either the effects of the times, or inven-  
“ tions of the poets, but as sacred relicks, or abstracted  
“ airs of better times, which by tradition from more  
“ ancient nations, fell into the trumpets and flutes of  
“ the Grecians.”

The observations of this great philosopher on the wisdom of the ancients, seems to coincide with the preceding ideas, relative to the state of learning and science in remote antiquity—that several branches thereof were brought to a considerable degree of perfection, in ages much anterior to any history or tradition now extant ; but have become so far mutilated by length of time and sundry occurrences, that only a few scraps thereof remain, as the vestiges of ancient sciences.

Indeed the remains of those ancient buildings, the Egyptian pyramids, and the ruins of Palmira and Balbec, are so many incontestible evidences of the antiquity and perfection of arts and sciences. The former being planed and executed on the best geometrical principles for duration ; and the latter are so elegantly planed and executed, that they are esteemed as standards in the science of archi-

architecture in the present age. The former are said to have been erected much beyond the reach of history: and the latter are said to be of such great antiquity as to render the æra of their erection very obscure and doubtful.

Now it appears to be a matter worthy consideration, that these noble magnificent edifices are constructed upon geometrical principles; since it will be readily granted, that the science of geometry was known and brought to a considerable degree of perfection before it was applied to the construction of these buildings: therefore since the science of geometry and its application in the above instances is so very obvious, may we not reasonably presume, that the same scientific principles might have been applied in the investigation of philosophical subjects: and particularly in demonstrating the magnitude and figure of the earth, from the laws of gravity, fluidity, and centrifugal force. Indeed when we consider the coincidence arising between the result of physical reasoning, and the doctrines advanced by the Phenicians and the Egyptians, we may deem it as a certain truth, that those doctrines were originally the result of philosophical reasonings, and were not the invention of poets: for in the first place, they could not have been obtained by tradition alone, as mankind were not an eye witness of the chaotic state of the earth; and

and in the second place, there are no other principles in nature yet known, whence such doctrines could have been derived.

Hence we conclude that the sciences of geometry and philosophy were known in ages much anterior to history or tradition: in favour of which opinion some other instances will appear in the course of this work.

But these considerations are rather a digression from the subject before us; therefore we will now return to the chaotic state of the earth, and endeavour to ascertain whether its component parts were created *homogeneous* or *heterogeneous*, as being a necessary preliminary to the ensuing researches.

### C H A P. III.

*Of the component Parts of the Chaos, whether homogeneous or heterogeneous.*

**H**AVING endeavoured to shew, that the terraqueous globe was originally *a fluid, chaotic, undivided mass*, composed of all things blended together, so as to render it totally unfit for animal or vegetable life, we have now to consider, whether its *component parts were homogeneous or heterogeneous*, as a necessary step towards a general investigation of the subject.

If

If the component parts of the chaos were created homogeneous, or endued with one universal quality, affinity or sameness, we might thence conclude, that according to the immutable laws of nature, they would necessarily have remained of one universal denomination to the end of time: and so in like manner if they were created heterogeneous, or induced with a variety of principles, or laws of elective attraction, they would necessarily have remained of different qualities or affinities to the end of time.

These axioms being granted, it remains now to ascertain whether the component parts of the earth are homogeneous, or heterogeneous: for whatever qualities or affinities are found to exist in the particles of matter, we may thence infer from the unalterable laws of nature, that the component parts of the chaos were endued with similar principles, or laws of attraction.

Now, no truth in nature is more obvious, than that the component parts of the earth are induced with a variety of principles, or laws of elective attraction; though they are equally and universally governed by one and the same law of gravitation.

But these are truths indeed, more known to chymists than to many other classes of mankind: and therefore some account thereof becomes requisite, in order to shew the principles on which the arrangement of matter into various substances depend.

The

The celebrated chymist, M. Macquer, has laid down the laws of affinity, or elective attraction, as so many propositions, necessary to the investigation of many natural phenomena, or the effects produced by different combinations of matter; upon which principles alone, the separation of the chaos into air, water, &c. is wholly founded. This eminent author observes, in his Elements of Chymistry, vol. 1. p. 12, that,

“ All experiments hitherto made concur with daily observation to prove that different bodies, whether principles or compounds, have such a mutual conformity, relation, affinity, or attraction, if you will call it so, as disposes some of them to join and unite together, while they are incapable of contracting any union with others. This effect, whatever be its cause, will enable us to account for, and connect together, all the phenomena that chymistry produces. The nature of this universal affection of matter is distinctly laid down in the following propositions.

“ First, If one substance has any affinity or conformity with another, the two will unite together, and form one compound.

“ Secondly, It may be laid down as a general rule, that all similar substances have an affinity with each other, and are consequently disposed to unite; as water with water, earth with earth, &c.

“ Thirdly,

“ Thirdly, Substances that unite together, lose some  
“ of their separate properties ; and the compounds result-  
“ ing from their union partake of the properties of those  
“ substances which serve as their principles.

“ Fourthly, The simpler any substances are, the more  
“ perceptible and considerable are their affinities : whence  
“ it follows, that the less bodies are compounded, the  
“ more difficult it is to analyze them ; that is, to  
“ separate from each other, the principles of which  
“ they consist.

“ Fifthly, If a body consist of two substances, and to  
“ this compound be presented a third substance, that  
“ has no affinity at all with one of the two primary sub-  
“ stances aforesaid, but has a greater affinity to the other  
“ than those two substances have to each other, there  
“ will ensue a decomposition, and a new union : that is,  
“ the third substance will separate the two compounding  
“ substances from each other, coalesce with that which  
“ has an affinity with it, form therewith a new combi-  
“ nation, and disengage the other, which will then be  
“ left at liberty, and such as it was before it had con-  
“ tracted any union.

“ Sixthly, It happens sometimes that when a third  
“ substance is presented to a body consisting of two sub-  
“ stances, no decomposition follows ; but the two com-  
“ poundng substances, without quitting each other,

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unite

“ unite with the substance presented to them, and form  
“ a composition of three principles: and this comes to  
“ pass when that third substance has an equal, or nearly  
“ equal, affinity with each of the compounding sub-  
“ stances. The same thing may also happen even when  
“ the third substance hath no affinity but with one of the  
“ compound substances only. To produce such an  
“ effect, it is sufficient that one of the two compounding  
“ substances have to the third body a relation equal, or  
“ nearly equal, to that which it has to the other com-  
“ poundung substance with which it is already combined.  
“ Thence it follows, that two substances, which, when  
“ apart from all others, are incapable of contracting any  
“ union, may be rendered capable of incorporating to-  
“ gether in some measure, and becoming parts of the  
“ same compound, by combining with a third substance  
“ with which each of them has an equal affinity.

“ Seventhly, A body, which of itself cannot decom-  
“ pose a compound consisting of two substances, because,  
“ as we just now said, they have a greater affinity with  
“ each other than it has with either of them, becomes  
“ nevertheless capable of separating the two by uniting  
“ with one of them, when it is itself combined with  
“ another body, having a degree of affinity with that one  
“ sufficient to compensate its own want thereof. In  
“ that case, there are two affinities, and thence ensues a  
“ double decomposition and a double combination.”

Such

Such are the constant invariable laws impressed upon matter of all denominations, now existing, whether solids or fluids. And we have much reason to suppose, that upon the various combinations thereof, all the phenomena in the visible parts of the material world actually arise.

Hence we may conclude, that since the laws of nature are unalterable; the presumption is great, that the component parts of the chaos were *heterogeneous* or *endued with the same variety of elementary principles*, or laws of elective attraction, as above represented, notwithstanding they are equally governed by one and the same universal law of gravitation.

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#### C H A P. IV.

*Of the Chaos, whether instantaneously or progressively formed into an habitable World.*

**I**N the preceding chapters we have endeavoured to shew that the earth was originally a fluid, chaotic, heterogeneous mass, totally unfit for animal or vegetable life; therefore it becomes requisite to inquire, whether the chaos was instantaneously or progressively formed into an habitable world.

No one will presume to doubt but that the same BEING who created matter, and governs it by immutable laws, might have formed the chaos into an habitable world in a moment of time had he so pleased.

It is not however the busines of philosophy to inquire what the DEITY might have done, with respect to the formation of the earth, but to discover if possible, by what mode he is pleased to act, in the continuation and government of his works: for by whatever mode the operations of nature are continually carried on, we may thence conclude, that by the same mode the chaos was formed into an habitable world.

A little observation will satisfy the most inquisitive mind that the operations of nature are progressive in the production of animal, vegetable, and mineral substances. The plants and fruits of the earth rise to maturity from their seeds, or first principles, in a regular uniform progression: and we have many obvious instances of the progressive formation of stone, and minerals, in the bowels of the earth; for instance,

i. The springs at Matlock-Bath in Derbyshire, tho' extremely pellucid and friendly to the human constitution, are nevertheless plentifully saturated with calcarious matter, which readily adheres to vegetables and other substances immersed in their streams, and thus, by a constant accretion, large masses of stone are gradually

formed. The banks on which the bath-houses stand, and likewise the buildings themselves, are mostly composed of such materials.

2. The lime-stone *strata* in Derbyshire, and in many other parts of England, abound with the *exuviae* of marine animals, or the impressions of them, in the solid substance of the stone; and we have likewise several instances related by authors, of the bones of terrestrial animals, and also of wood, having been found enveloped in *strata* of stone.

3. A complete human skeleton, with British beads, chains, iron rings, brass bits of bridles, &c. were dug up in a stone-quarry, near the Earl of Widrington's seat, at Blankney in Lincolnshire.

4. Human bones and armour, with Roman coin, *fibulae*, &c. were found in a stone-pit, in the park at Hunstanton, in Norfolk, supposed to have been buried in the earth after a battle. Baddan's Abridg. Philos. Trans. vol. vi. p. 444.

5. In the mountains of Canne, half a league from Meastrick, the *vertebræ* of a crocodile, thirty feet long, was found in a *stratum* of sand-stone, well preserved.

6. The remains of a Crocodile were also found in a *stratum* of stone at Blenheim, the seat of his Grace the Duke of Marlborough; and are now in the possession of the learned Mr. Bryant.

7. The

7. The beds of argillaceous stone, &c. incumbent on coal, contain a great variety of figured fossils, representing different species of the vegetable creation.

8. The constant accumulation of mineral substances in the caverns and fissures of the lime-stone *strata* is no less evident than the stony concretions.

9. The stalactites which hang from their lofty roofs, as icicles from the eves of houses, are continually increasing in number and magnitude; and the bottoms and sides of the caverns are daily incrusting with spar, and other mineral substances. Such operations of Nature may be conveniently observed in those celebrated caverns called Pool's Hole, near Buxton, and Peak Hole, at Castleton.

10. Many of these subterraneous caverns and fissures are also incrusted with alternate *laminæ* of spar, lead ore, zinc ore, pyrites, fluor, and other substances, and in these recesses they crystallize in various forms, peculiar to the nature, or affinities of their component parts.

Were we allowed to reason upon the general cause of these wonderful appearances, we should be apt to conclude from the various circumstances accompanying them, that they arise from water filtrating slowly thro' the incumbent *strata*; and taking up in its passage a variety of mineral substances, and becoming thus saturated with metallic particles, gradually exuding on the surface of

of the caverns and fissures, in a quiescent state, the aqueous particles evaporate, and leave the mineral substances to unite according to their affinities.

Hence a variety of mineral substances are daily forming in select bodies, though in one general mass, one part thereof consisting of spar, another of fluor, lead ore, the ore of zinc, crystal, or whatever substances may happen to have been collected by the water, in its passage through the incumbent *strata*.

Such crystallization however depend in some measure on the quantity of water exuded through the pores of the stone; for if the quantity exuded exceeds the quantity evaporated, stalactites are produced in one instance, and tubes in another.

The latter are thus formed. If a drop of water hangs from the roof, and remains suspended, but nearly dropping, the aqueous particles evaporating from the surface thereof sooner than from its interior parts, the mineral particles therefore unite on the surface of the drop, while the interior part remains fluid, the water thus detained is continually increasing and gradually extends in length downwards. The process thus going on frequently forms tubes one or two feet in length, and about one tenth of an inch diameter.

Such phenomena as above recited, evidently shew that all beds of stone were originally in a state of fluidity to receive

receive the bodies thus entomb'd, and therefore serve to corroborate the conclusions we have drawn in Chap. I. And they, likewise, together with the mineral productions, abundantly testify that the operations of nature are progressive in all the visible parts of the material world.

Whence it appears that the chaos was not *instantaneously*, but *progressively* formed into an habitable world.

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## CHAP. V.

*Of the Separation of the Chaos into select Bodies of various Denominations, viz. Air, Water, Earth, and other Substances.*

HAVING premised the general laws or principles bestowed upon matter; whereby the material world is constantly and invariably governed: and having likewise attempted to investigate the original state of the earth, or the mode of its first existence, beginning, and the equability of its annual and diurnal revolutions: we shall endeavour to trace the progressive operations of nature in the separation of the chaotic mass into air, water, earth, and other select substances, as pre-

preparatory steps towards unfolding the formation of the chaos into an habitable world.

The first operation which apparently presents itself to our consideration, is the figure of the earth ; for according to proposition the second, page 9, the fluid mass no sooner began to revolve upon its axis, than its component parts began to recede from their axis of motion, and thus continued till the earth had acquired its present oblate spheroidal form. The two forces then became equally balanced, and the equilibrium of gravitation restored.

The component parts of the chaos being thus arrived at a state of rest with respect to the effects arising from gravity, and centrifugal force, began more immediately to act according to their affinities, or the laws of elective attraction ; for according to proposition the second, page 24, particles of a similar nature attract each other more powerfully than those of contrary affinity, or quality.

But to illustrate this doctrine, let us suppose that if a variety of salts were dissolved in one and the same menstruum, or mass of water, it will come to pass that particles of a similar nature will unite and form the same select substances as they were before solution ; provided the menstruum remains perfectly quiescent. But on the contrary no union will take place amongst them, for the particles of the several salts will remain in a state of

solution, equally diffused throughout the whole mass of water: rest being so essentially necessary to the union of similar substances.

These matters being duly considered, it will evidently appear, that the component parts of the chaos no sooner became quiescent than similar particles began to unite, and compose bodies of various denominations; that is to say, the particles of *air* united with those of *air*, those of *water* with *water*, and those of *earth* with *earth*; and with their *union commenced their specific gravities.*

The uniform suspension of the component parts, which had hitherto prevailed throughout the chaotic mass, being thus destroyed by the union of similar substances, bodies of the greatest density began their approach towards the center of gravity, and those of the greatest levity ascended towards the surface.

Thus apparently commenced the separation of the chaos into *air*, *water*, *earth*, and other select bodies.

Now since the specific gravity of air, is to that of water, nearly as 1 to 800; therefore, according to the laws of statics, the former became freed from the general mass in a like proportion of time sooner than the latter, and surrounded the terraqueous globe with a *muddy impure atmosphere.*

The

The process of separation still goes on, and the earth consolidates every day more and more towards its center, and its surface became gradually covered more and more with water, until the sea prevailed universally over the earth.

Thus by the union of similar particles, the atmosphere and the ocean seem to have been separated from the general mass, in successive periods of time; and were progressively freed from all impurities, and rendered perfectly fit for animal life.

To the laws of elective attraction we may likewise ascribe that sameness of quality which prevails in *strata* of different denominations, as calcareous, argillaceous, &c. and also the assemblage of all other particles into select bodies of metals, minerals, salts, talks, spars, fluors, crystals, diamonds, rubies, amethysts, &c. and likewise many other phenomena in the natural world.

Having thus endeavoured to trace the operations of nature in separating the component parts of the chaos, and arranging them into select classes of different denominations; it becomes a matter of some importance to consider, that as the sun is the common center of gravity, or one of the great governing principles in the planetary system; we may thence infer that the governing body was at least coeval with the bodies governed.

Therefore as the chaos revolved upon its axis during the *period of its separation into air and water*, and their becoming freed from all gross matter and rendered fit for animal life, we may thence reasonably infer, that as the atmosphere was progressively freed from heterogeneous substances, light and heat gradually increased every day more and more, until the sun became visible in the firmament, and shone with its full lustre and brightness upon the face of the new-formed globe.

Such appearing to have been the natural order and progression of these things, the presumption is great, that light, and likewise several days and nights preceded the sun's appearance in the firmament; which seems to corroborate the scripture account of the creation; namely, that of several days and nights preceding the creation of the sun and moon, or their becoming visible on the fourth day of creation. How far the result of this reasoning may serve to illustrate the Mosaic account, we readily submit to the candid reader.

Before we conclude this chapter, it may not be unworthy of the reader's attention to consider in what particular part of the chaos the laws of elective attraction began first to operate.

We have already observed that quiescence is an essential requisite to the union of similar substances; and therefore as the central parts of the chaos were more quiescent than

than those nearer to the surface, we may thence infer, that the laws of affinity began to operate sooner in the central parts than in those near the surface: therefore it seems repugnant to the laws of nature, that the central part of the earth should consist of water only, and the exterior part of a shell or crust, as some have imagined.

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## C H A P. VI.

*Of the Formation of the Primitive Islands.*

HAVING endeavoured to trace the progressive operations of nature in the formation of the atmosphere and ocean, and in rendering them perfectly pure and fit for animal life; we have now to consider the formation of the Primitive islands for the reception of the terrestrial animal, and vegetable kingdoms.

According to the result of the preceding chapter, the sea universally prevailed over the earth: therefore in order to investigate the origin of the Primitive islands, let us suppose for the present, that during the separation of the atmosphere and the ocean from the chaotic mass, that the earth was perfectly free from the *attractive influence of all other bodies*; or that nothing interfered with the uniform law of its own gravitation.

Under

Under such circumstances it will necessarily follow, that as the chaos was an uniform pulp, the solids would equally subside from every part of its surface, and consequently become equally covered with water.

On the contrary, if the sun and the moon were coeval with the earth, as before suggested, their attractive influence would necessarily interfere with the regular uniform subsiding of the solids: for as the separation of the solids and fluids increased, so in like manner the tides would increase, and remove the solids from place to place without any order or regularity.

Hence the sea became unequally deep; and those inequalities daily increasing, in process of time dry land appeared, and divided the sea, which had hitherto prevailed universally over the earth.

Such we conceive to have been the consequences necessarily arising from the chaotic state of the earth, and its coexistence with the sun and the moon.

Whence we may reasonably infer, that the Primitive islands were formed by the flux and reflux of the tides, as sand-banks are daily forming in the sea; and consequently could not acquire any considerable extent, or elevation, compared to the mountains and continents now existing in the present state of the earth; but as so many uniform protuberances gradually ascending from the deep.—No craggy rocks, stupendous cliffs, or im-

pending shores were then existing, to curb the boisterous waves, but the whole surface of the earth was smooth, even and uniform; the *strata* not yet arranged, and minerals only existed in their elementary principles.

Such we presume was the state of the Primitive islands, which in process of time became firm and dry, and fit for the reception of the animal and vegetable kingdoms.

Having thus endeavoured to trace the operations of nature in forming the chaos into an habitable world; we cannot pass over in silence, the great analogy which prevails between the *Mosaic account of the creation, and the result of the preceding deductions*: for the same series of truths which are asserted in the former, are hereby deduced from the laws and operations of nature.

From this obvious agreement between revelation and reason, in so many essential points, we may reasonably infer, that they both flow from the same fountain, and therefore can never operate in contradiction to each other. Consequently, by which ever means the same truths are brought to light, be it by revelation or reason, they will perfectly coincide, and that coincidence may be considered as a testimony of the truth of each.

CHAP.

## C H A P. VII.

*Of the general Order or Succession in which Land and Sea Animals were created. And of their Entombment in the Bowels of the Earth.*

ACCORDING to the preceding chapters, the atmosphere, sea, and land, were brought to maturity for the reception of the animal and vegetable kingdoms, in successive periods of time. Let us therefore endeavour to ascertain the general order or succession in which they were severally created.

This inquiry is particularly brought forward, as containing many corroborating testimonies relative to the preceding conclusions, with respect to the original state and formation of the earth, and the progressive order in which the several elements were separated from the chaos, and rendered perfectly pure and fit for animal and vegetable life.

The phenomena on which this reasoning principally depends, are the *exuviae* of marine and *terrestrial animals* entombed in the solid substance of *stone*, *chalk*, *clay*, *gravel*, and *sand*, in all parts of the world; upon mountains, in vallies, and deep recesses of the earth, both near and remote from the sea.

On

On the agreement of such facts with the laws and operations of nature, the subject of the present inquiry must stand or fall: therefore much depends upon a faithful examination of the several phenomena relative to fossil bodies. For instance,

1. In what substances animal and vegetable remains are found; as in what denomination of stone, chalk, clay, sand, or gravel.
2. Whether the shells, bones, and teeth of fish retain their native matter, or whether become wholly or in part changed to the substance of the *strata* in which they are imbeded.
3. Whether the remains of marine and terrestrial animals are found intermixed in the same *stratum*.
4. Whether a bed of fossil shells consist of one select species, or more than one; and whether the bivalves are united and appear whole, or only as the fragments of shells.
5. To observe whether such *exuviae* are natives of the climate where found, or of distant regions of the earth.

Such are the appearances upon which the present inquiry depends: therefore in order to obtain the several ends proposed, it becomes necessary to recite the observations of some eminent naturalists on fossil shells and other animal *exuviae*, as well as those which have occurred in the course of my own inspection, in various parts of England.

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But

But previous thereto, let us suppose for the present that marine animals were created prior to the Primitive islands, or while the sea prevailed universally over the earth; in order to consider the consequences thence arising, with respect to the *exuviae* of marine animals.

The generality of marine animals being naturally prolific, and having an unlimited field for their support; they might probably increase and multiply so exceedingly in a short space of time, as to replenish the ocean from pole to pole.

And if the ocean were thus plentifully stocked with inhabitants previous to the appearance of dry land, it may be presumed, that many of these animals became daily enveloped and buried in the mud, by the daily action of the tides; according to Chap. VI.

Hence it appears, that the deeper the Primitive ocean, the greater space of time elapsed before the islands were formed; and the deeper these marine bodies were entombed.

And, as the different species of marine animals are endued with different degrees of activity, those particular species which were the least active, would consequently be the least able to defend, or extricate themselves from such interments.

Therefore since all species of shell fish are much less active than the finny kinds, the former were probably thus entombed in much greater numbers than the latter.

Such

Such we presume would have been the consequences necessarily arising from the creation of marine animals, prior to the appearance of dry land: and therefore when it is considered, that according to Chap. V. the sea prevailed universally over the earth; it seems highly probable that these marine inhabitants were enveloped and buried in the mud in all parts of the sea, from pole to pole.

And if they were thus buried and deprived of life, in successive periods of time, they must necessarily be found in different states of decay, and their native testaceous matter become more or less changed to the substance of the *strata* wherein they are included.

Having proceeded thus far hypothetically, by supposing that marine animals were created prior to the Primitive islands; it remains now to inquire into the various phenomena relative to the *exuviae* of marine animals, and thence to conclude whether the preceding conjectures are true or fallacious.

According to the concurring testimony of many eminent naturalists; fossil shells and other marine relicks, have been observed in all parts of the world hitherto explored; even upon the highest mountains and in parts remote from the sea; likewise in vallies and deep recesses of the earth, imbeded in the solid substance of lime-stone, chalk, clay, and gravel. But that in every instance we

have hitherto observed, the fragments of sea shells are infinitely more numerous than the bones and teeth of fish. The latter too are but rarely deposited in any other matter than in beds of sand and gravel; and not in the solid substance of lime-stone, as the shells of fish generally are, even to the depth of many hundred yards, and dispersed throughout the whole extent of the *Strata*: Of which the cliffs and caverns in Derbyshire, Staffordshire, and almost every other country productive of lime-stone, exhibit innumerable instances: but of which more hereafter.

The observations of Count Buffon, the celebrated naturalist, on the subject of fossil shells and other marine *exuviae*, contain many valuable and interesting facts. He says,

“ 1. Fossil shells are found on the Alps, on the top  
“ of mount Cenis, on the Apennines, on the mountains  
“ of Genoa, and in most of the quarries of stone and  
“ marble in Italy; in most parts of Germany and Hun-  
“ gary, and indeed generally in all the elevated places in  
“ Europe. We also find them in the stones whereof the  
“ most ancient edifices of the Romans were constructed.

“ 2. In Switzerland, Asia and Africa, travellers have  
“ observed petrified fish, in many places: for instance,  
“ on the mountains of Castravan, there is a bed of white  
“ laminated stone, and each *lamina* contains a great num-  
ber

“ ber and diversity of fishes; they are, for the most  
“ part very flat, and extremely compressed, in the man-  
“ ner of fossil fern; yet they are so well preserved, that  
“ the minutest marks of their fins and scales are distin-  
“ guishable, and every other part, whereby one species  
“ of fish is know from another.

“ 3. There are likewise many *echenites* and petrified  
“ fish between Iver and Cairo, and on all the hills and  
“ heights of Barbary, most of which exactly correspond  
“ with the like species taken in the Red Sea.

“ 4. The long chain of mountains, which extend  
“ from east to west, from the lower part of Portugal  
“ quite to the most eastern parts of China, those which  
“ stretch collaterally to the north and south of them,  
“ together with the mountains of Africa and America,  
“ which are now known to us, all contain *strata* of  
“ earth and stone, full of shells.

“ 5. The islands of Europe, Asia, and America,  
“ wherein Europeans have had occasion to dig, whether  
“ in mountains or plains, all furnish us with shells, and  
“ convince us that they have this particular in common  
“ with their adjacent continents..

“ 6. The *glossoptra*, or the teeth of sharks, and of  
“ other fishes, are found in the jaws, polished and worn  
“ smooth at the extremities; consequently must have  
“ been made use of during the animal’s life; and in the  
“ shells,

“ shells, the very pearls are found, which the living  
“ animals of the same kind produce.

“ 7. It is well known that the *purpura* and *pholades*  
“ have a long pointed proboscis, which serves them as a  
“ kind of gimblet or drill, to pierce the shells of living  
“ fish, on whose flesh they feed. Now shells thus  
“ pierced are found in the earth, which is another incon-  
“ testible proof that they heretofore inclosed living fish,  
“ and that these fish inhabited places where the *purpura*  
“ and *pholades* preyed on them.

“ 8. In Holland sea shells are found an hundred feet  
“ below the surface at Merly-la-Ville, six leagues from  
“ Paris, at seventy-five; and in the Alps and Pyrenean  
“ mountains they are found under beds of stone of an  
“ hundred, nay even a thousand feet.

“ 9. Shells are likewise found in the mountains of  
“ Spain, France, and England; in all the marble quar-  
“ ries in Flanders; in the mountains of Guilders; in all  
“ the hills round Paris; in those of Burgundy and  
“ Champagne; and, in short, in all places where the  
“ basis of the soil is neither *freestone* nor *sandstone*.

“ 10. By shells I would be understood to mean, not  
“ only those which are merely testaceous, but the relicks  
“ of the crustaceous fishes also; and even all other ma-  
“ rine productions: and I can venture to assert, that in  
“ the generality of marbles there is so great a quantity of  
“ ma-

“ marine productions, that they appear to surpass in  
“ bulk the matter whereby they are united.

“ 11. Amongst the many instances of the multiplicity  
“ of oysters, there are few more extraordinary than that  
“ immense bed which M. de Reaumur gives an account  
“ of, which contains 130,630,000 cubic fathoms.  
“ This vast mass of marine bodies is in Touraine in  
“ France, at upwards of thirty-six leagues from the sea.  
“ Some of these shells are found so intire, that their  
“ different species are very distinguishable.

“ 12. Some of the same pieces are found recent on  
“ the coast of Poictou, and others are known to be na-  
“ tives of more distant parts of the world. Amongst  
“ them are likewise blended some fragments of the more  
“ stony kinds of sea plants, such as *madripores*, *fungi*  
“ *marini*, &c. The canton of Touraine contains full  
“ nine square leagues in surface, and furnishes these frag-  
“ ments of shells, wherever you dig.” Thus far M.  
Buffon. See his Natural History.

We shall, however, be less astonished at this very considerable quantity of shells, when we consider the vast increase of shell fish. It is not uncommon to take away a bed of these shell fish, several fathoms in thickness ; and though the places where they are fished for appear to be intirely exhausted, yet, in the ensuing year, there shall be as many found in all these places

as before: nor do I remember to have heard that any place whence they were taken, had ever been intirely exhausted.

“ 13. Near Reading in Berkshire, a continued body  
“ of oyster-shells has been found; they lie in a *stratum*  
“ of greenish sand, about two feet in thickness, and ex-  
“ tend over five or six acres of ground; they are covered  
“ by *strata* of sand and clay, upwards of fourteen feet  
“ deep: several whole oysters are found with both their  
“ valves or shells lying together, as oysters before they  
“ are opened; the shells are very brittle, and in digging  
“ them up, one of the valves will frequently drop from  
“ its fellow. Several are dug out entire; nay some  
“ double oysters, with their valves united.” And,

“ 14. In a quarry at the east end of Broughton in  
“ Lincolnshire, innumerable fragments of the shells of  
“ shell fish, of various sorts, are found under a *stratum*  
“ of stone embodied in clay, with pieces of coral, and  
“ sometimes whole shell fish, with their natural shells  
“ and colours: some are most miserably cracked, bruised  
“ and broken; others totally squeezed flat by the incum-  
“ bent weight of earth.” Lowthorp’s Abridg. Phil.  
“ Trans. vol. ii. p. 428.

“ 15. Sharks teeth are dug up in the isle of Sheppey,  
“ retaining their natural colour not petrified.

“ 16. The

16. "The teeth of sharks, have likewise been taken out of a rock in Hinderskelf Park, near Malton in Yorkshire." *Ibid.* p. 430.

17. "In the isle of Caldey, and elsewhere about Tenby in Pembrokeshire, marine fossils have been found in solid marble, on the face of the broken sea cliffs, *two hundred fathoms* below the *upper surface of the rocks*. Nor were they only observed upon the face of these rocks, but even more or less throughout the whole mass or extent of them. This is manifest from divers rocks hewn down by workmen for making of lime, and other pieces casually fallen from the cliffs." And,

18. "Thousands of fossil teeth, exactly answering to those of divers sorts of sea fish, have been found in quarries and gravel-pits about Oxford." *Ray, 3 Dis.* p. 178. 182.

19. "At Thame in Oxfordshire, the *belemnites*, or thunderbolt stones, are found in a *stratum* of blue clay, which still retain their native shelly substance.

20. "The *belemnites* found in gravel pits, have suffered much, by their being rubbed against each other in the fluctuation of waters.

21. "The *nautili* and *belemnites* are frequently found at Garsing near Oxford." *Philosophical Transactions, vol. liv.* p. 5.

22. "At Westbere, an obscure village, about three miles east of Canterbury, many oysters and other shells were dug up, at a considerable depth, together with an *iron anchor*: and another anchor was dug at Broom Down, on the same side the level.

23. "Hardel Cliff, in Hampshire, contains a great variety of turbinated and bivalve shells, which still retain the native matter and colour of marine shells; many of these are natives of very distant regions, and others of them are not known to exist in a living state.

24. "In some parts of Suffolk, I am told, fossil shells are so numerous, that they are dug up for manure, and produce excellent crops. These shells retain much of their native marine matter; they are much decayed and blunted, as shells by rolling on the sea coast.

25. "Sheppey Isle, and other parts of Kent, abound with fossil shells, which still retain their native colour and consistence; likewise the teeth and *vertebræ* of fish, and, in particular those of the shark; also the remains of crustaceous fishes, as crabs, lobsters, &c.

26. "In a hill called Catsgrove, in Berkshire, a great number of oysters are dug up entire, but crumble into dust, when exposed to the air. In the same place are also found periwinkle shells, whose spirals are reversed to those in the adjacent sea.

27. "Rung-

27. "Rungwell Hill, in Surry, is said to contain  
"oyster shells not petrified, nor much decayed, and so  
"like to oysters newly taken from the sea, that they  
"have been opened for such, in expectation of finding  
"living fish therein." Ray, 3 Dif. p. 129.

28. Near Stableford, the seat of the Earl of Harborough, several beds of sea shells were lately discovered, inclosed in calcarious earth; these shells still retain their native marine matter, though much decayed. The limestone *strata* in that neighbourhood abound with different species of fossil shells, in a petrified state.

29. Many parts of Northamptonshire contain fossil shells, in great abundance, in part and wholly petrified, and, in particular, a species of oyster, said to be a native of the Mediterranean Sea. I have in my possession a fragment of a *Cornu-Ammonis*, dug up near Northampton, which retains its native shell.

30. In Sir Ashton Lever's excellent Museum, there are several curious specimens of the *Cornu-Ammonis*, with their native shelly matter remaining: such instances are rare, and of great value, by pointing out the origin of them.

31. "In some parts of Virginia, for several miles together, the soil is so intermixed with oyster shells, that there seems to be as great a quantity of shells as of earth: how deep they lie thus intermixed, I think, is not yet known; for in the broken banks they are

“ continued many yards perpendicular. In several places  
“ the shells are much closer, and being petrified, seem  
“ to form a *stratum* of stone. I have seen, in several  
“ places, veins of these rocky shells, three or four yards  
“ thick, at the foot of an hill, whose perpendicular  
“ height might be twenty or thirty yards. Of these rocks  
“ of oyster shells that are not so much petrified, they  
“ burn and make all their lime.

32. “ Often in the looser banks of shells and earth,  
“ are found perfect teeth petrified, some of them not less  
“ than two or three inches long, and above one inch  
“ broad; the part that one might suppose to grow out of  
“ the jaw was polished, and black almost as jet, the  
“ other brown, and not so smooth.

33. “ The back-bone of a whale, and several ribs,  
“ were dug up out of the side of a hill several yards deep,  
“ about four miles distant from James-Town and the  
“ river. Another back-bone of a whale, and several  
“ teeth, were found in hills beyond the falls of James-  
“ River, at least one hundred and fifty miles up the  
“ country.” Lowthorp’s Abridg. Philos. Transl. vol.  
iii. p. 581.

34. “ Fossil bones and shells of several sorts, have  
“ been found in Maryland; some of them have received  
“ little alteration in the earth, others more, and some  
“ were so changed as to be stony; but all of them re-

“tained their ancient shape. Some of them were com-  
“pared to the tongue and palate of a fish observed at  
“Jamaica, and found perfectly analogous to each other.”  
Lowthorp's Abridg. Phil. Trans. vol. ii. p. 431.

35. “Naphat, a remarkable mountain in Ireland, said  
“to be elevated several hundred fathoms above the level  
“of the sea; yet, within ten yards of the top of this  
“mountain, there are several vast beds of marine shells  
“of various kinds: as whelks, muscles, cockles, &c.  
“and parallel to these are those vast mountains in Virgi-  
“nia, and other parts of America.”

36. In the mountainous tracts of Derbyshire, and in  
the Moorland of Staffordshire, I have frequently observed  
with astonishment enormous masses of lime-stone  
composed almost intirely of fossil shells or other marine  
relics; diffused throughout the solid substance of the  
*strata*: And it is likewise observable that, in many instances  
these masses of stone will sometimes abound with  
one select species, of cockles, *entrochis*, corralines, &c.

37. And others of them with a variety of species con-  
fusedly blended together.

The former instance is notorious in the Derbyshire  
marble, wherein the *entrochis* are alone conspicuous.  
And wherever the bivalve species are observed with both  
their valves intire and close as the shells of living fish, they  
likewise form select classes.

38. But

38. But in every instance wherein the beds of shells consist of several species blended together, the valves are not united, but separate from each other, as the fragments of shell fish when assembled together in the sea, by the fluctuation thereof.

39. I have likewise observed in a *stratum* of shale, or indurated clay, at Claxby in Lincolnshire, great numbers of fossil shells which perfectly retain the native colour, figure, and consistence of marine shells. The same *stratum* likewise contains nodules of iron-stone, which are generally accompanied with vitriolick acid, and which seems to have operated in some degree upon the exterior part of the shells, so as to divest them of their external brown crust, and to exhibit that of a pearly colour only. This *stratum* of shale was perforated seventy yards deep in search for coal, and such remains as above described were formed to that extraordinary depth; how much deeper the shale and the shells might continue, has not hitherto been ascertained. Though the shells are apparently in high preservation, the shale is covered by an incumbent *stratum* of lime-stone, fifteen or twenty yards thick.

40. I may add to the above that I have also observed somewhat similar phenomena in very many other parts of England, but they are so extremely notorious that it is altogether needless to relate any more such instances.

41. Though

41. Though fossil shells are so extremely numerous in every part of the world, yet, so far as my observations have extended, the bones and teeth of fish are never intermixed therewith in the solid substance of lime-stone, and rarely under any other circumstances, but with adventitious bodies.

42. In the isle of Sheppey the teeth of sharks, and the bones of fish are frequently gathered at the foot of the mouldering cliffs, not petrified, but much tarnished as it were with pyrites, or vitriolick acid, which vanishes by the operations of air, or weather. The above cliffs are composed of argillaceous earth, and contain a variety of extraneous bodies, insomuch that the whole of the island seems to be an assemblage of adventitious matter. I have found therein several pieces of petrified wood which have been apparently wrought, and have been originally much perforated by sea worms. And this idea, is abundantly corroborated by the timber lately found at Sheerness three hundred feet deep, by sinking a well for the purpose of obtaining fresh water..

43. The isle of Sheppey contains a great variety of fossil bodies belonging to the animal and vegetable kingdoms, which evidently shew it to be an assemblage of adventitious matter.

The remains of marine animals imbeded in the solid substance of stone, chalk, and clay, and in sand, gravel,,

vel; &c. in all parts of the known world, are so extremely numerous, that it seems altogether needless to add any more instances relative to their origin: let us therefore proceed to a recapitulation of the several facts, in order to draw some general conclusions concerning them.

1. Fossil bodies resembling both in substance and shape the shells of living fish, are found imbeded upon the highest mountains, in vallies and deep recesses of the earth, remote from the sea.

2. They are found retaining the native testaceous matter, colour, and figure of marine shells; insomuch as not to have been distinguished from the shells of living fish, and have even been opened for such, in expectation of finding living fish therein.

3. Fossil shells are also found in various states of decay, and variously impregnated with stony or metallic matter, and even wholly changed to the substance of the stone in which they are imbeded.

4. They are found in the solid substance of the limestone *strata*, dispersed throughout their whole extent and thickness, though some of them are not less than 150 or 180 feet thick, of which see Chap. XVIII. They are also involved in *strata* of chalk and clay.

5. The bivalve species are sometimes found with both their shells intire and close, as those of living fish: and when thus found, each bed consists of one particular species;

cies; namely, oysters, cockles, muscles, &c. selected together, as the same species are actually assembled together in the sea.

6. But on the contrary, when beds of fossil shells are composed of fragments or separate bivalves, they consist of a great variety of species confusedly blended together, in like manner as the fragments of sea shells are thrown together by the fluctuation of the ocean.

7. Fossil bones and teeth, resembling those of fish, are also found retaining the perfect colour, figure and polish of recent teeth, and even apparently worn by use: but though the number of such fossil bodies are very considerable, yet those resembling the shells of fish are infinitely more numerous: and I have not been able to discover from my own observations a single instance of the former being imbeded with the latter, in the solid substance of the lime-stone *strata* in Derbyshire, or elsewhere; but constantly with a variety of adventitious matter near the surface of the earth.

8. And we may add to the above, that the remains of terrestrial animals are seldom or never found intermixed with marine relicks, in the lime-stone *strata*; neither are those of the sea ever found, or but rarely, in the argillaceous *strata* containing the impressions of vegetables.

I

Such

Such are the general phenomena attending the above fossil bodies; whence the following inferences seem to arise.

First, Their great analogy in figure, colour, and consistence, to the shells, bones and teeth of living fish, together with a gradual change in their component parts, from a testaceous, to a stony, or metallic substance, evidently shew that all such fossil bodies were originally productions of the sea.

Secondly, Their being found in all parts of the world, even imbeded in the highest mountains, vallies, and deep recesses of the earth, remote from the sea, evidently shews that the sea prevailed universally over the earth, according to Chap. V. and consequently, that these marine animals were created prior to the Primitive islands, and likewise prior to terrestrial animals, agreeable to the scripture account of the creation.

Thirdly, And since they are found at various depths in the earth, even to that of several thousand feet, and in different states of decay, and variously impregnated with stony or metallic matter, and even changed to the substance of the stone in which they are imbeded; it evidently appears, that the *strata* were originally in a state of fluidity, and that they were thus entombed and deprived of life in successive periods of time, according to the preceding conjectures, page 40.

I

Fourthly,

Fourthly, The beds of fossil shells which consist of one species only, and are not natives of the climate where found, but of very distant regions of the earth, evidently shew that they were generated, and have lived and died, in the very beds where found, and could not have been removed from their native climates by a flood, or floods of water with so much order, as to form beds consisting of only one select species ; and therefore all such beds must have been originally the bottom of the ocean.

Such are the inferences deduced from the preceding facts ; which tend to corroborate the several results arising from the former parts of this inquiry, into the original state and formation of the earth : namely, that the earth was originally a fluid chaotic mass, totally unfit for animal or vegetable life.—That it was progressively formed into an habitable world.—That marine animals were created prior to the Primitive islands, and consequently prior to terrestrial animals.—That they were entombed in the bowels of the earth, in successive periods of time, and before dry land appeared.

I say this agreement of facts with the laws and operations of nature, and also with the Mosaic account of the creation ; leave little room to doubt, but that the inferences contained in the preceding pages have some foundation in nature and truth : therefore, notwithstanding any errors I may have committed in the arrangement of

the facts, or in the inferences thence deduced; yet, I flatter myself, that the subject matter thereof will sometime or other be rendered equally as permanent and satisfactory to a rational mind, as any mathematical demonstration whatever.

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## C H A P. VIII.

*General Observations on the superficial and interior Parts  
of the Earth.*

**N**Otwithstanding the conclusions we have drawn in the preceding chapter, have so much the appearance of truth, nevertheless, some objections may possibly arise in the minds of those readers who have been accustomed to consider *mountains* and *continents*, as *primary* productions of Nature. Such readers I presume may probably reason thus with themselves :

“ If the fossil shells which are found imbeded in the  
“ tops of the highest mountains were actually generated,  
“ and have lived and died, in the very beds wherein they  
“ are found, those beds must have been originally the  
“ bottom of the ocean; and if so, pray, whence pro-  
“ ceed all these vast alterations on the superficial parts  
“ of

“ of the earth? Why hath the sea descended so far beneath those mighty eminences, the *Alps*, the *Andes*, the *Pyreneans*, &c. and why hath it retired from those extensive tracts of land, the *continents*? Were not these things originally thus created? If not, pray whence proceed these great inequalities? History is silent concerning such events; and tradition is too faint to rest much proof upon it; therefore, since we have no written evidence to help us in the scrutiny, and tradition itself fails us through age, we cannot wholly assent to the preceding conclusions, until these apparent objections are removed.”

To such candid inquirers I beg leave to answer, that whoever attentively views and considers the present state and condition of the terraqueous globe; its craggy rocks and mountains, its steep, angular and impending shores, subterraneous caverns, &c. will be almost persuaded, without any farther inquiry, that these romantic appearances are not the effects of a regular uniform law, but of some tremendous convulsions, which have thus burst its *strata*, and thrown their fragments into all this confusion and disorder: nay, the very representation of sea and land, upon a geographical chart, seems alone sufficient to establish the truth of such a conjecture.

Let us not, however, take those things for granted which we are able to investigate from a series of undeniable

niable facts: it is one thing to assert a truth, and another to prove it; the former leaves the mind in a state of suspense, the latter in possession of *truth*.

But before we attempt to investigate the cause of these wonderful appearances, let us endeavour to recollect the general state and condition of them.

We are told that "Norway abounds with stupendous "rocks and mountains, as it were cloven asunder, or "cut with saws, both across and lengthways. Some of "them are remarkable for their appearances; on the "left hand, sailing up Joering Creek, there appears such "a group of the crests of mountains, as resemble the "prospect of an old city, with towers and Gothic edi- "fices: some of them are continually covered with "snow, whilst the chasms in others make way for the "light to penetrate.

"The sea shore too, is almost every where steep, an- "gular, and impending, insomuch that the water, close "to the rocks, is generally three or four hundred fa- "thoms deep; and in Floge Creek no bottom can be "found with a line of one thousand fathoms.

"Nordall Creek is also said to be nine hundred fa- "thoms deep; and other creeks, which run thirty miles "up the country, are also said to be three or four hun- "dred fathoms deep; and the bottom of the sea and "other waters in that country consist of rocks, moun- "tains,

“tains, and vallies, like the land.” Thus far Bishop Pontoppidion’s History of Norway.

We are also told, that many other parts of the world are in a similar state to those of Norway.

The mountains in Derbyshire, and the moorlands of Staffordshire appear to be so many heaps of ruins, and more especially the latter; for, in the neighbourhood of Ecton, Wetton, Dovedale, Ilam, and Swithamly, the *strata* lie in the utmost confusion and disorder. They are broken, dislocated, and thrown into every possible direction, and their interior parts are no less rude and romantic; for they universally abound with subterraneous caverns; and, in short, with every possible mark of violence. The caverns near Buxton and Castleton, and the subterraneous rivers, the Manifold and the Hamps, are familiar instances of the present state and condition of those parts of the globe. The former river, after a passage of four or five miles from the north, and the latter about the same distance from the west, both emerge at the foot of the same cliff, in the garden of John Port, Esq; of Ilam, about the distance of twenty yards from each other.

We may add, to the above phenomena, those large blocks of stone which are scattered over the surface of the earth, in mountainous countries, and mingled with their respective soils to very considerable depths, as if they had been

been originally ejected from their native beds by subterraneous blasts, as stones are frequently ejected from Vesuvius, *Aetna*, or any other such powerful agents.

The above fragments are attended with the following singular circumstances. Those which lie near their native beds are too numerous and massy for the hand of man to have placed them there, and they lie in as much disorder as stones casually thrown together. The banks on the east side of the river Derwent, from Crich Cliff, twenty miles up the river, are thus covered; and the same phenomena may be observed on the sides of many other mountains in Derbyshire and Staffordshire.

As these stones lie so near their original *stratum*, we may easily satisfy ourselves that they are detached parts thereof; and, by analogy, the more distant fragments may be ascertained with equal certainty, though at the distance of ten or twenty miles.

In the neighbourhoods of Uttoxeter, in Staffordshire, blocks of lime-stone are frequently dug up four or five hundred weight each; and yet I cannot learn that there are any quarries of the same kind of stone nearer than four or five miles.

Fragments of stone perfectly analogous to the former, were dug up at Etwall in Derbyshire. A well being sunk to the depth of eleven yards, many of these stones were found intermixed with other adventitious bodies

bodies, from the surface of the earth to that depth, some of them were six or eight pounds weight, and some smaller. Now although Etwall cannot be less than fifteen or twenty miles from any known quarry of the same kind, we cannot help concluding that they were originally ejected to that distance; since such effects are frequently produced by subterraneous explosions: and what makes this conjecture more probable is, the same phenomena have been observed in other wells in that village.

I have frequently observed in the neighbourhood of Stafford, and Newport in Shropshire, detached blocks of Cornish moor-stone, or granite, of considerable magnitudes, though no such *stratum* is known to exist nearer than Cornwall.—And such extraneous substances are not peculiar to Derbyshire, Staffordshire, and Shropshire, for they abound in many other parts of England; and particularly in the County of Chester, in which the fragments of blue quartzore stone seems to be universally intermixed with its soil; for wherever pits or wells are dug to obtain water, or its rivers wash down their adjacent banks, such stones are usually found.

The generality of these fragments are rounded as it were by attrition, as stones upon a sea beech, and are usually applied to the paving of streets, public roads, &c. Some of these detached blocks are not less than fifteen or twenty hundred weight each. I have observed a *stratum*

*tum* similar to the above, in the north part of Wales, and upon the Reken in Shropshire. But not the least appearance of such a *stratum* in Cheshire, the soil of which is in general composed of adventitious matter, apparently assembled together by the fluctuation of water, of which we shall give some notorious instances in the future part of our work.

The phenomena above recited may be considered as so many instances of the great alterations which the earth has undergone by subterraneous convulsions.

But these supposed events, or great revolutions, having happened anterior to history, render some inquiry into the effects recently produced by subterraneous convulsions necessary, in order to compare the appearances of the former with the effects of the latter, and this, as the only means of obtaining a permanent idea, of the real cause of such phenomena.

But the subject of this inquiry we reserve for the ensuing chapter.

CHAP.

## C H A P. IX.

*Of the Alterations produced on the superficial Parts of the Earth, since the Commencement of History, by Means of subterraneous Convulsions.*

WE learn from Pliny, and many other natural historians, that the superficial parts of the earth have suffered considerable alterations and changes at sundry periods of time, viz.

First, That many mountains have been raised, and others depressed, or totally swallowed up into the bowels of the earth; together with cities and large districts of land; and that navigable lakes have appeared in the places thereof.

Secondly, That many mountains have been shivered to pieces, and the fragments thereof thrown into the adjacent vallies, and in some instances even to the distance of ten, twenty, or thirty miles.

Thirdly, That great cliffs or fissures have been burst open, and that rivers of boiling water and melted matter have flowed from thence, and deluged the adjacent countries with liquid fire, or water; and likewise, that great agitations of the sea, and also of lakes and rivers,

K 2 have

have frequently accompanied those tremendous convulsions of nature: and in some instances the sea has overflowed its natural bounds, and deluged the adjacent country, and even conveyed ships of considerable burden many miles into the interior parts thereof.

Such have been the notorious effects arising from subterraneous convulsions in all preceding ages, from the first commencement of history down to the present æra: and therefore both the interior and exterior parts of the earth have suffered considerable alterations and changes compared with its primitive smoothness and regularity, according to the result of Chap VI.; as the following instances will evidently shew.

But let us first recite a few recent marks of violence, in order to strengthen the credibility of those which are said to have happened in the more early ages of the world.

1. We are told, that during the dreadful earthquake, which destroyed Lisbon, on the first of November 1755, "the mountains of Arrabida, Estretta, Julio, Marvan, "and Cintra, being some of the largest in Portugal, "were impetuously shaken as it were to their very foundations; and some of them opened at their summits, "split, and rent in a wonderful manner, and huge "masses of them were thrown down into the adjacent "vallies." Hist. and Phil. of Earthquakes, p. 317.

2. "A fine new stone quay in Lisbon, where the  
"merchants landed their goods, where at that time  
"about three thousand people were assembled for safety,  
"was turned bottom upwards, and every one lost; nor  
"did so much as a single body appear afterwards."

Phil. Trans. vol. xlix. p. 412.

3. "A sea port, called St. Ubals, was intirely swal-  
"lowed up, people and all." Ibid, p. 413.

4. "About eight leagues from Morocco, the earth  
"opened, and swallowed up a village, with all its inhabi-  
"tants (who were known by the name of the sons of  
"Busunba), to the number of eight or ten thousand  
"persons, together with their cattle of all sorts, as ca-  
"mels, horses, horned cattle, &c. and soon after the  
"earth closed again, in the same manner it was be-  
"fore." And,

5. "One of the Sarjon Hills was rent in two; one  
"side of which fell upon a large town, where there was  
"the famous sanctuary of their prophet, known by the  
"name of Mula Teris; and the other side of the said  
"hill fell down upon another large town, and both  
"towns and inhabitants were all buried under the said  
"hill." Ibid, p. 431.

6. "The famous city Tasso was wholly swallowed  
"up; no remains being left." Phil. Trans. vol. xlix.  
p. 432.

We

We have likewise many other authentic accounts of this fatal and extensive earthquake, in the periodical papers.

7. "The grand city of Mequinez is no more, it was  
"buried in the bowels of the earth, on the nineteenth  
"of November (1755), by a violent shock of an earth-  
"quake, which likewise swallowed up, at several  
"leagues distance, two camps of moving Arabs, up-  
"ward of four hundred tents, containing twenty-five or  
"thirty persons each, with a large tract of country."  
Universal Mag. vol. xvii. p. 282.

8. "At Mequinez, that part of the city where the  
"Jews resided, was entirely swallowed up, and all the  
"people of that sect (about four thousand in number)  
"perished, except seven or eight." Ibid, vol. xviii.  
p. 28.

9. "In the year 1692, a great part of Port-Royal  
"in Jamaica was sunk by an earthquake, and remains  
"covered by water several fathoms deep; some chimnies  
"and masts of ships excepted, which appear above water.  
"On the north side, above 1000 acres of land sunk. Some  
"mountains along the river, betwixt Spanish-Town and  
"Sixteen-mile Walk were joined together; and others  
"so thrown on heaps, that people were forced to go by  
"Guanaboa to Sixteen-mile Walk. At Yellows, a  
"great mountain split, and fell into the level land, and  
"covered several settlements. Another plantation was  
"removed

“ removed half a mile from the place where it formerly  
“ stood. In Clarendon precinct the earth gaped prodi-  
“ giously; and all over the island there were abundance  
“ of openings; nay, many thousands; but in the  
“ mountains are said to have been the most violent  
“ shakes: indeed they are strangely torn and rent, inso-  
“ much that they seem to be of different shapes now,  
“ from what they were, especially the Blue and other  
“ highest mountains, which seem to have been the great-  
“ est sufferers. And a large high mountain near Port-  
“ morant, near a day’s journey over, is said to be quite  
“ swallowed up; and in the place where it stood there is  
“ now a great lake, of four or five leagues over. The  
“ Blue and its neighbouring mountains used to afford a  
“ fine green prospect; now one half part of them at  
“ least seem to be wholly deprived of their natural verdure.  
“ There one may see where the tops of great mountains  
“ have fallen, sweeping down all the trees, and every  
“ thing in their way, and making a path quite from top to  
“ bottom.” Lowthorp’s Abr. Phil. Trans. vol. ii. p. 417.

10. “ In the year 1699, seven hills were sunk by an  
“ earthquake, in the island of Java, near the head of  
“ the great Batavian river, five on this side and two on  
“ the other. And nine more were likewise sunk on this  
“ side the Tangarang river. Between the Batavian and  
“ Tangarang rivers, the land was rent and divided asun-  
“ der,

“ der, with great clefts, more than a foot wide.”  
 Lowthorp’s Abridg. Phil. Trans. vol. ii. p. 419.

11. “ In the year 1538, the famous town called St. Euphemia, situate at the side of the bay, under the jurisdiction of the Knights of Malta, was totally swallowed up, with all its inhabitants, and nothing appeared but a stinking lake in the place of it.” Dr. Hooke’s Post. p. 306.

12. “ The Pico, in the Moluccos, accounted of equal height with that of Teneriffe, was sunk by an earthquake, and quite swallowed up into the earth, and left a lake in its place.” And,

13. “ In the year 1646, many of those vast mountains of the Andes were quite swallowed up and lost.”  
*Ibid*, p. 307.

14. “ The 11th of January, 1693, a mighty earthquake happened in Sicily, and chiefly about Catanea: the violent dancing of the earth threatened the whole island with intire desolation. The earth opened in several places, in very long clefts, some an hand’s breadth, others half a palm, others like great gulphs. In the plain of Catanea, water was thrown from those long clefts, altogether as salt as the sea. Great rocks were thrown down every where, and in the country of Lotino, a great number of people perished in the houses beaten down by the rocks rolling down the hills.

A great

“ A great number of noble structures lie, like a horrid  
“ desert, in vast heaps of ruins, and not less than  
“ 59,969 persons were destroyed by the fall of them, in  
“ the different parts of Sicily.” Lowthorp’s Abridg.  
Phil. Trans. vol. ii. p. 408, 409.

Having enumerated a few recent instances of the alterations produced on the superficial parts of the earth, by subterraneous convulsions, we may venture to recite those which happened in the more early ages of the world.

Pliny has not only recorded many extraordinary phenomena which happened in his own time, but has likewise borrowed many others from the learning of more ancient nations.

15. “ A city of the Lacedemonians was destroyed by  
“ an earthquake, and its ruins wholly buried by the mountain Taygetus falling down upon them.” Pliny’s  
Nat. Hist. chap. lxxix.

16. “ Many strange effects ensue from earthquakes :  
“ in one place the walls of cities are laid along ; in another they are swallowed up in deep and wide chasms :  
“ here are cast up mighty heaps of earth ; there, are  
“ let out rivers of water, and sometimes of fire ; in another place, the course of rivers are changed. The  
“ chasms sometimes remain wide open, and shew what  
“ hath been swallowed up ; at other times they close up

L

“ again,

“ again, and conceal all that is contained in them, and  
 “ no visible marks thereof remain, notwithstanding they  
 “ have many times devoured cities, and whole tracts of  
 “ land.” Pliny’s Nat. Hist. chap. lxxx.

17. “ I found in the books of the Tuscan learning,  
 “ an earthquake recorded, which happened within the  
 “ territory of Modena, when L. Martius and S. Julius  
 “ were consuls, which repeatedly dashed two hills against  
 “ each other. With this conflict all the villages, and  
 “ many cattle were destroyed ; and this happened the  
 “ year before the war of our associates : which I doubt  
 “ whether it were not more pernicious to the whole land  
 “ of Italy than the civil wars. This event happened in  
 “ the day-time, and was observed by many Roman gen-  
 “ tlemen.” And,

18. “ No less a wonder happened in our age, in the  
 “ very last year of Nero the emperor ; when meadows  
 “ and olive rows (notwithstanding the great public port-  
 “ way laid between them) passed into each others place,  
 “ in the Marrucine territory.” Ibid, chap. lxxxiii.

19. “ The greatest earthquake in man’s memory was  
 “ that which happened during the reign of Tiberius  
 “ Cæsar, when twelve cities of Asia were laid level in  
 “ one night.” Ibid, chap. lxxxiv.

The preceding instances may serve to shew that mountains, cities, and large districts of land, having been swallowed

lowed up from time to time, in various parts of the world ; and others which have been clove asunder, shivered to pieces, and their fragments thrown into the adjacent vallies ; let us now enquire what other effects have been produced by these dreadful convulsions of nature.

20. " Those famous islands Delos and Rhodes are said to have grown out of the sea ; and afterwards those that were less, namely, Anaphe beyond Melos, and Nea between Lemnus and Hellespont. Alone, also, between Lebedus and Peos. Thera likewise and Therasia, among the Cyclades, which first appeared in the fourth year of the 135th Olympiad. Moreover among the same isles, 130 years after, Hiera : and two furlongs from it, after 110 years, Thia, even in our time, upon the eighth day before the ides of July, when M. Junius Syllanus, and L. Balbus were consuls." Pliny's Nat. Hist. chap. lxxxvii.

This truly eminent author has also recorded many other considerable alterations which have happened on the superficial parts of the earth, at different periods of time ; but, for brevity sake, they are here omitted, being of such remote antiquity. To proceed.

21. " In the year 726 the island Hiera was enlarged to twice its former dimensions by the addition of another island, which united so well to it, that there remains no other mark of its joining than a cleft or fissure,

“ sure, which reaches from one end of the island to the  
“ other, and in several places is not six inches wide.  
“ And

22. “ In the month of December, 1427, this island  
“ called Hier, or the Burnt Island, was again encreased  
“ by great rocks raised up by subterraneous fires. The  
“ same thing happened again in the year 1457: but  
“ with this difference, that the subterraneous fire, after  
“ having raised to the height of five or six feet above the  
“ water, a vast quantity of rocks, which formed a  
“ space about a mile in circumference, opened a pas-  
“ sage for the sea water to enter, by which it was extin-  
“ guished. And also

23. “ In the year 1573 another island was formed,  
“ called the Lesser Burnt Island.” Motte’s Abridg.  
Phil. Trans. vol. ii. part iv. p. 200.

24. “ From the 24th of September to the 9th of  
“ October, 1650, the island of Santirinum, formerly  
“ called by Pliny Thera, was dreadfully shaken with  
“ earthquakes, so that the inhabitants expected nothing  
“ but utter ruin, and were yet more amazed to see a  
“ horrid eruption of fire out of the bottom of the sea,  
“ about four miles to the eastward of the island; previ-  
“ ous to the appearance of fire, the water was consider-  
“ ably elevated in that place, and the wave spreading  
“ itself round every way; overturned every thing it met,

“ destroying ships and galleys, in the harbour of Candia,  
“ which was eighty miles distant. The eruption filled  
“ the air with ashes and horrible sulphureous vapours,  
“ and dreadful lightnings and thunders succeeded. All  
“ things in the island were covered with a yellow sul-  
“ phureous crust. Multitudes of pumice and other  
“ stones were thrown up, and carried as far as Constan-  
“ tinople, and to places at a great distance. The force  
“ of this eruption was greatest the two first months,  
“ when all the neighbouring sea seemed to boil; and the  
“ volcano continually vomited up fire-balls: upon the  
“ turning of the wind, great mischief was done in the  
“ island of Santeritum; many beasts and birds were  
“ killed: and on the 29th of October, and 7th of No-  
“ vember, fifty men were killed by it. The other four  
“ months it lasted, though much abated of its former  
“ fierceness, yet it still cast up stones, and seemed to  
“ endeavour the making of a new island, which though  
“ it do not yet perfectly appear above water, yet 'tis co-  
“ vered but eight feet by the water. It is also said, the  
“ sea, in that place, was before fathomless.” Dr. Hooke's  
Post. p. 302.

25. “ In the year 1707, another island was discover-  
“ ed, where it is said, the sea was eighty or an hundred  
“ fathoms deep. This island continually increased in  
“ height and breadth, for the space of three years; in  
“ which

“ which time it became six miles in circumference, and  
“ of considerable height. And,

26. “ The island Santorini itself is said to be composed  
“ of burnt rocks and pumice-stones.” Motte’s Abr.  
Phil. Trans. vol. ii. part iv. p. 200.

27. “ In the year 1628, one of the islands of the  
“ Azores, near the island of St. Michael, rose up from  
“ the bottom of the sea, which, in that place, was 160  
“ fathoms deep; and this island, which was raised in  
“ fifteen days, is three leagues long, a league and a half  
“ in breadth, and rises 360 feet above the water.” Sir  
William Hamilton’s Observations on Vesuvius and  
Ætna, p. 159.

28. “ On the 20th of November 1720, a subterranean fire burst out of the sea near Tercera, one of the  
“ Azores, which threw up such a vast quantity of  
“ stones, &c. in the space of thirty days, as formed an  
“ island about two leagues diameter, and nearly round.  
“ Prodigious quantities of pumice-stone and half-broiled  
“ fish were found floating on the sea, for many leagues  
“ round the island.” Eames’s Abr. Phil. Trans. vol. vi.  
part ii. p. 203.

29. “ Another example of the same kind happened  
“ at Manilla, one of the Philippine islands, in the year  
“ 1750. This eruption was attended with violent  
“ earthquakes, to which that island, as well as the rest  
“ of

“ of the Philippines, is very much subject.” Rev. Mr. Michell’s Conjecture on Earthquakes, p. 16.

30. We may add to the above, the vast quantities of pumice-stones, which have been sometimes found floating upon the sea, at so great a distance from the shore, as well as from any known volcano, that there can be little doubt of their being thrown up by fires subsisting under the bottom of the ocean.

31. “ Mr. Garwin relates, that in the year 1726, a Dutch captain sailing above eighty leagues from the cape of Good Hope, found the sea covered with pumice-stones, through the space of six hundred leagues.” Bertrand’s Dict. of Fossils, vol. ii. p. 126.

32. “ In the year 1538, a subterraneous fire burst open the earth near Puzzoli, and threw up such a vast quantity of ashes and pumice-stones, mixed with water, as covered the whole country, and thus formed a new mountain, not less than three miles in circumference, and almost as high as mount Barbaro, near a quarter of a mile perpendicular height. Some of the ashes of this volcano reached the vale of Diana, and some parts of Calabria, which are more than 150 miles from Puzzoli.” Sir Wm. Hamilton’s Observations, p. 128.

The few instances we have related of islands being raised in the ocean by subterraneous fires, strengthen our

our conjectures concerning the origin of those islands and mountains, which have a volcanic appearance, and are supposed to have been produced from the same cause, anterior to history, viz. Iceland, Fyal, &c. in the Northern Sea; St. Helena and Ascension islands, between Africa and Braſil; Easter or Davis's island, Otaheite, &c. in the Southern Ocean; several of the Moluccas, in the Indian Sea; Madeira, several of the Azores and the Antilles, &c. in the Atlantic Ocean; the Lipari islands, Ischæi, &c. in the Mediterranean Sea.

The above may serve to put the reader in mind of recollecting many other islands which have ſimilar appearances; and likewife to ſhew that ſubterraneous fires actually exist under the bottom of the ocean, in various parts of the world; and that others may have been extinguiſhed time immemorial: let us therefore return to a more particular inquiry concerning the phenomena produced by ſubterraneous fires at land.

33. "The eruption of Vesuvius, in the year 79, "overwhelmed the two famous cities Herculaneum "and Pompeii, by a shower of ſtones, cinders, ashes, "ſand, &c. and totally covered them many feet deep, "as the people were ſitting in the theatre. Hercula- "neum is ſaid to have been ſituate about four miles "from the crater, and Pompeii at the distance of ſix "miles; yet the latter appears to have been covered by  
that

“ dreadful eruption ten or fifteen feet deep ; and the former, by that and subsequent eruptions, lies buried sixty or seventy feet deep. By the violence of this eruption, ashes were carried over the Mediterranean Sea, into Africa, Egypt and Syria ; and at Rome they choaked the air on a sudden, so as to hide the face of the sun, to the great terror of the inhabitants, who knew not the cause thereof, having not received the news from Campania.” Burnet’s Sacred Hist. vol. ii. p. 85, 86.

34. “ In the year 1632, rocks were thrown to the distance of three miles from Vesuvius.” Baddam’s Abridg. Phil. Transl. vol. iii. p. 68.

35. “ In the year 1631, a stone was thrown twelve miles from the crater of Vesuvius, and fell upon the Marquis of Lauro’s house at Nola, which it set on fire. And,

36. “ In the year 1767, a solid stone, measuring twelve feet in height, and forty-five in circumference, was thrown a quarter of a mile from the crater of Vesuvius. The eruption of 1767, though by much the most violent in this century, was, comparatively to those of the years 79 and 1631, very mild.” Sir Wm. Hamilton’s Observations, p. 49.

37. “ In the year 1533, large pieces of rock were thrown to the distance of fifteen miles, by the volcano

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“ Cotopaxi

“ Cotopaxi in Peru, and covered the plain of Latacunga ; and near Hambato the earth opened in several places, of which there still remains an astonishing monument, on the south side of the town, being a chasm or cleft, four or five feet wide, and about a league in length.” Ulloa’s Voyage to Peru, vol. I. p. 324, 329.

38. “ In 1669, stones of sixty palms in length were thrown from the crater of Ætna, to the distance of one mile, and stones of less size to the distance of three miles. This eruption was accompanied by a great darkness which continued many weeks. Alphonsus Borellus, a learned mathematician of Pisa, went into Sicily, while the fact was fresh, to view and survey what Ætna had done ; and he says, the quantity of matter thrown out at that time, upon survey, amounted to 93,838,750 cubical paces ; so that had it been extended in length upon the surface of the earth, it would have reached farther than 93,000,000 of such paces, which is more than four times the circuit of the whole earth, taking 1000 paces to a mile : ’tis true, all this matter was not liquid fire, but in part sand, stone, gravel, &c. however he computes 63,000,000 paces of this matter were liquid fire, and formed a river, sometimes two miles broad, according to his computation ; but according to the observation of others, “ who

“ who also viewed it, the torrent of fire was fix or seven  
“ miles broad, and sometimes ten or fifteen fathoms deep,  
“ and it forced its way into the sea near one mile, pre-  
“ serving itself alive in the midst of the waters. He like-  
“ wise observes, that a stone fifteen feet long was flung  
“ out of the pit to a mile distance; and when it fell, it  
“ came from such an height, and with such violence, that  
“ it buried itself in the ground eight feet deep.” Burnet’s Sacred Theory, vol. ii. p. 82, 83.

39. “ Olaus Wormius, a learned writer, gives an ac-  
“ count of an earthquake in Iceland, which filled the air  
“ with dust, earth, and cinders, and overwhelmed towns,  
“ fields, and even ships, a good way distant on the sea;  
“ and which sent forth its fumes with such violence, and  
“ in such quantities, as covered all the decks and sails of  
“ ships lying on the coast of Norway, tho’ not less than  
“ 600 miles distant.” And,

40. Considerable as the above eruptions may appear, yet a much greater quantity of matter seems to have been thrown out by a volcano in Peru. “ In the year 1600, an earthquake happened at Arequepa in Peru, accom-  
“ panied with an eruption of sand, ashes, &c. which continued during the space of twenty days, from a volcano breaking forth. The ashes falling in many places above a yard thick, and in some more than two, and where least above a quarter of a yard deep, which

“ buried the corn-grounds of maize and wheat. The  
“ boughs of trees were broken, and the cattle great  
“ and small died for want of pasture. For the sand  
“ and ashes thus erupted, covered the fields 90  
“ miles one way, and 120 miles another way.  
From this account it appears that the space of ground  
thus covered with sand and ashes was at least equal to  
the area of a circle whose diameter is 210 miles; and its  
area, nearly equal to 34,636 square miles: and since  
that space was wholly covered from six feet to nine  
inches deep, *where least*; we may thence infer that a  
much greater extent of ground was covered, though in  
a less degree. These circumstances being duly consider-  
ed, may enable us, in some degree, to estimate the  
whole quantity of matter erupted, at 34,636 square  
miles in breadth, and three feet in depth. The quan-  
tity of matter being thus computed exceeds that which  
flowed from Etna in the year 1669, upwards of 1140  
times. “ During the above eruption which continued  
“ near 20 days, mighty thunders and lightnings were  
“ heard and seen, ninety miles round Arequepa: and  
“ it was so dark whilst the showers of ashes and sand  
“ lasted, that at mid-day candles were burnt to do bu-  
“ siness.” Dr. Hooke’s Post. p. 304.

41. “ A mountain in Java, not far from the town  
“ of Panacura, in the year 1586, was shattered to pieces  
“ by

“ by a violent eruption of glowing sulphur (though it had never burnt before) whereby 10,000 people perished in the under-land fields. It threw up large stones, and cast them as far as Pancras.” Varenius’s Geog. vol. i. p. 150.

Thus the fragments of the stony *strata*, together with sand, ashes, &c. have been spread over the surface of the earth at sundry periods of time, by means of subterraneous convulsions; and therefore, since there are no other operations in nature yet known, whence such effects have been produced, may we not thence infer, that all similar appearances on the superficial parts of the earth have arose from similar causes; notwithstanding there are no vestiges of ancient volcanos now remaining in many parts of the world where the fragments of the *strata* are thus scattered about.

Were it possible to enumerate all the existing volcanos in the different regions of the earth, together with those which have been apparently extinguished time immemorial, and likewise the many instances we have had of new volcanos bursting forth, not only in various parts of continents and islands, but also in the bottom of the ocean, we should be apt to conclude, that subterraneous fires either do, or have heretofore existed universally in the bowels of the earth.

We have therefore much reason to infer, from the great analogy which prevails between the effects produced

ced by those stupendous operations of nature, and the romantic appearances on the superficial parts of the earth, described Chap. VIII, that the latter were as certainly the effects of subterraneous fires as the former.

It must however be owned, that notwithstanding the great analogy between the real effects produced by subterranean convulsions, and the appearances observed on the surface of the earth, that the former, when compared with the latter, as the Alps, the Andies, &c. in point of magnitude, they seem to vanish, or become too inconsiderable to stand in competition with them.

Whence it appears, that subterraneous convulsions operated more violently in the early ages of the world, than they have done since the commencement of records.

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## C H A P. X.

### *Of the Alterations produced on the superficial Parts of the Earth anterior to History.*

**I**N the preceding chapter we have endeavoured to enumerate some of the most considerable alterations which have been produced on the superficial parts of the earth by subterraneous convulsions, since the commencement of history, in order to observe the analogy between those effects, and the general state and condition of the

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terraqueous globe, with respect to its craggy rocks, mountains, vallies, and all other disorderly appearances, and from thence to infer the general cause of those inequalities.

Whence it appears, that, notwithstanding the stupendous effects produced by subterraneous convulsions since the commencement of history, they are much inferior to those produced anterior to any historical monument whatever; as the following instances abundantly testify. Let us therefore proceed to such observations as have a tendency to establish the effects above suggested.

These remote operations of nature already mentioned, seem to have but recently attracted the attention of European philosophers, though so essentially necessary to the investigation of many natural phenomena, on the superficial parts of the earth.

M. Condamine seems to have been the first naturalist who has favoured the world with any observations on this subject: for although Italy has been considered as the seat of learning and polite arts for many centuries, and has been visited as such, by all the learned of Europe; yet the natural history thereof seems not to have been the object of inquiry before the year 1755. Since that period the subject has been resumed by the Honourable Sir William Hamilton, his Majesty's Plenipotentiary at the Court of Naples, and carried to a much greater length.

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However, since the observations of M. Condamine are truly ingenious, and also prior to those of Sir William Hamilton, we think it a compliment due to that celebrated naturalist, to give them the first place in the present researches. The former, in his tour to Italy in the year 1755, writes thus,

“ All the mountains and hills about Naples, will be  
“ found, upon examination, to be huge heaps of mat-  
“ ter, vomited out by volcanos, which are now extinct,  
“ whose eruptions, anterior to history, seem to have  
“ formed the ports of Naples and Puzzoli. It is not in  
“ Naples alone, and its neighbourhood, that I have met  
“ with such like substances. As my eyes have been ac-  
“ customed to distinguish the different emanations of  
“ Vesuvius, and especially the lava, under its variety of  
“ aspects, I could trace it with ease and certainty the  
“ whole way from Naples to Rome, even to the very  
“ gates of the latter, sometimes pure, and again com-  
“ bined with other substances.

“ The whole inside of the mountain Frascati, where  
“ was Cicero’s Tusculum; the chain of hills which ex-  
“ tend from Frascati to Grotta-Ferrata, Castel-Gon-  
“ dolfo, and even to the lake Albano; a good part of  
“ the mountain Tivoli; those of Capravola, Viterbo,  
“ &c. consist of beds of calcined stones, pure ashes,  
“ cinders, gravel, a substance like iron drofs, terra-

“ cotta, and lava properly so called: in a word, so like, in all respects, to the composition of the soil of Portici, and to the materials which have issued out of the sides of Vesuvius, under such a diversity of forms, that the sight alone is sufficient to distinguish all these several substances. The ashes are manifest, both from their colour and taste. - It is impossible for any one who has attentively examined the productions of Vesuvius, not to be satisfied of a perfect resemblance between them and those he will meet with at every step, in his way from Naples to Rome, from Rome to Viterbo, from Rome to Loretto, &c.

“ It then necessarily follows, that all this part of Italy has been ruined by volcanos. Those plains, now so smiling and fertile in olive-trees, mulberry-trees, and vines, like the hills at present about Vesuvius, have like them been overspread with burning inundations, and beat, as they do, not only within, but on their surface, infallible marks of fiery torrents, whose waves are now fixed and consolidated, bearing testimony of vast ignitions, prior to all monuments of history.

“ When I see, on an elevated plain, a circular basin, surrounded with calcined rocks; the verdure with which the neighbouring fields are covered, impose not on me: I instantly perceive the ruins of an ancient volcano, as I should perceive, beneath the snow itself,

“ the traces of an extinguished fire, on seeing an heap  
“ of cinders.

“ If there be a breach in the circle, I usually find out,  
“ by following the declivity of the ground, the traces of  
“ a rivulet, or the bed of a torrent, which seems as it  
“ were hollowed in the rock; and this rock, when ex-  
“ amined closely, appears frequently to be nothing more  
“ than lava, properly so called.

“ If the circumference of the basin has no breach, the  
“ rain and spring waters which assemble there having no  
“ issue, generally form a lake in the very mouth of the  
“ volcano.

“ A few days after the sight of the lake Albano itself  
“ (and the calcined matter with which its banks are  
“ powdered, left no room to doubt any longer of its  
“ origin), I saw manifestly the profound funnel or shaft  
“ of an ancient volcano, in the mouth of which the wa-  
“ ters had accumulated themselves. Its eruption, of which  
“ history makes no mention, must have been ante-  
“ rior to the foundations of Rome, and even of Alba,  
“ from whence this lake has taken its name: a period  
“ amounting to near three thousand years.

“ At the sight of the traces of fire diffused in the en-  
“ virons of the lakes of Borsello, de Rociglione, and Brac-  
“ ciano, on the road from Rome to Florence, I had  
“ formed the same conjectures, before I had seen either  
“ Vesu-

“ Vesuvius, or the matter which it vomits forth. I pass  
“ the same judgment by analogy, on the lake Perugia,  
“ and several others in the interior part of Italy, which  
“ I only know by the map.

“ In short, I look upon the Apennines as a chain of  
“ volcanos, like that of the Cordeliers of Peru and Chi-  
“ ly, which run from north to south, the whole length  
“ of South America, from the province of Quito to the  
“ Terra Magellanica.

“ The course of the volcanos of the Cordeliers is in-  
“ terrupted; a great number of them are either extin-  
“ guished or smothered, but several still remain actually  
“ burning. The old ones also frequently revive and  
“ sometimes new ones are kindled, even in the bottom  
“ of the sea. Nor are their effects, on that account,  
“ less fatal.

“ A few years since both Lima and Quito, two capi-  
“ tal cities of Peru, became the victims of those two  
“ kinds of volcanos.

“ The chain of the Apennines which divides the con-  
“ tinent of Italy, in like manner from north to south, and  
“ extends as far as Sicily, presents us still with a pretty  
“ great number of visible fires under different forms.

“ In Tuscany the exhalations of Firenzuolo, and the  
“ warm baths of Piza in the ecclesiastical state, those

“ of Viterbo, Norcia, Nocera, &c. in the kingdom of Naples, those of Ischia, Solfatarra, Vesuvius; in Sicily and the neighbouring isles, Ætna, or mount Gibel, with the volcanos of Lipari, Stromboli, &c. But other volcanos of the same chain, having been quite extinguished from time to time immemorial, have left only some remains behind, which though they may not always strike at first sight, are not at all less distinguishable to attentive eyes.

“ In short, the earthquakes which at various times have over-run several of the cities of Italy and Sicily; that which swallowed up St. Euphemia in 1538; that which destroyed Catana in 1693; that which opened the gulphs of Palermo in 1718; and that which over-run Syracuse, recall to my remembrance the disasters of Valparaiso, Callao, Lima and Quito, in South America, and close the parallel between the Cordeliers of Italy and those of Peru: the features of resemblance are but too striking.

“ I do not affirm that all mountains are in the case of the Apennines; I could not observe the same appearances in that part of the Alps which I travelled over; but I have found the same in Dauphiny, Provence, and several places where they were never looked upon as the effects of fire. It is not therefore in Italy alone that the vestiges of calcination and vitrification are to

“ be

“ be met with, but also in places where volcanos have  
“ never been supposed to have existed ; France affords  
“ instances, and possibly most countries. My conjectures  
“ about the ancient volcanos of Italy, of which I find  
“ marks in all parts, and on the lava, which I discover-  
“ ed even in places where I the least expected it, appear  
“ to me so evident, that my only wonder was, they  
“ should be new. They were however looked upon as  
“ whims, in a country, where I still think, nothing  
“ more than the use of one’s eyes is necessary to produce  
“ the like,” &c.

Thus far the observations of M. Condamine; which are happily confirmed by those of his excellency Sir William Hamilton, who has also added many new and interesting observations on the ancient volcanos of Italy.

“ It would require,” says Sir William, “ many years  
“ close application to give a proper and truly philosophi-  
“ cal account of the volcanos in the neighbourhood of  
“ Naples ; but I am sure such an history might be given,  
“ supported by demonstration, as would destroy every sys-  
“ tem hitherto upon the subject. We have here an oppor-  
“ tunity of seeing volcanos in all their different states. I  
“ have been this summer in the island of Ischia ; it is  
“ about eighteen miles round, and its whole base is lava.  
“ The great mountain in it, near as high as Vesuvius, I  
“ am convinced, was thrown up by degrees ; and I have  
“ no

“ no doubt in my own mind, but that the island itself  
“ rose out of the sea; in the same manner as some of  
“ the Azores. I am of the same opinion with respect  
“ to mount Vesuvius, and all the high grounds near  
“ Naples; having not yet seen in any place, what can  
“ be called virgin earth. I had the pleasure of seeing a  
“ well sunk at the foot of Vesuvius, and close by the sea  
“ side. At twenty-five feet below the level of the sea,  
“ they came to a *stratum* of lava, and God knows how  
“ much deeper they might have still found other lavas.

“ At the convent of the Dominican friars, called Ma-  
“ dona del Arco, some years ago, in sinking a well, 100  
“ feet deep, a lava was discovered, and soon after ano-  
“ ther; so that in less than 300 feet deep, the lavas of  
“ four eruptions were found. From the situation of this  
“ convent, it is clear, beyond a doubt, that those lavas  
“ proceeded from the mountain called Somma, as they  
“ are quite out of the reach of the existing volcano.

“ From these circumstances, and from the repeated  
“ observations that I have made in the neighbourhood  
“ of Vesuvius, I am sure no virgin soil is to be found  
“ there, but that all is composed of different *strata* of  
“ erupted matter, even to a great depth below the level  
“ of the sea. In short, I have not any doubt in my  
“ own mind, but that this volcano took its rise from  
“ the bottom of the sea; and as the whole plain be-  
“ tween

“tween Vesuvius and the mountains behind Caserta, which is best part of Campania-Felice, is under its good soil composed of burnt matter; I imagine the sea to have washed the feet of those mountains, until the subterraneous fires began to operate, at a period certainly of the most remote antiquity.

“The mountains at the back of Caserta are mostly a sort of limestone, and therefore very different from those formed by fire; though Signor Van Vitelli, the celebrated architect, has assured me, that in cutting the famous aqueduct of Caserta through those mountains, he met with some soils that had been evidently formed by subterraneous fire.” Sir William Hamilton’s Observations on Vesuvius and Ætna.

“In the year 1689, as some workmen were digging a well near the foot of mount Vesuvius, a mile from the sea, in the spot where formerly stood the famous city of Pompeia, I observed,” says Francis Bianchini, a celebrated architect, “clodded earth and vitrified stone were laid in regular alternate *strata*, in the following order, viz.

		Palm.	Feet.	Inches.
1. Cultivated Earth	- - -	12	= 11	. 8
2. Black vitrified Stone	- - -	4	= 3	. 4
3. Solid Earth	- - -	3	= 2	. 6
4. Vitrified Stone	- - -	6 $\frac{1}{2}$	= 5	. 5
		<hr/>	<hr/>	<hr/>
		25 $\frac{1}{2}$	= 22	. 11
		<hr/>	<hr/>	<hr/>
			“ Under	

“ Under the fourth *stratum* were found some coals, “ iron door locks, and two inscriptions signifying that “ the city of Pompeia formerly stood there.—Proceed- “ ing further, the following *strata* were observed.

		Palm.	Feet.	Inches.
5. Solid Earth	- - - - -	10	=	8 . 4
6. Vitrified Stone	- - - - -	2 $\frac{1}{2}$	=	2 . 1
7. Earth stiffer than the former	-	8	=	7 . 8
8. Vitrified Stone	- - -	4	=	3 . 4
9. Earth more indurated	- - -	25	=	20 . 10
10. Vitrified Stone very heavy.	- - -	16	=	13 . 4
11. Soft Stone	- - - -	14	=	11 . 8
		79 $\frac{1}{2}$	=	67 . 3

“ Under which *stratum*, such plenty of water flowed “ into the well as put a final stop to any further re- “ searches.

“ The two inscriptions found at the depth of 25 $\frac{1}{2}$  “ palms, or twenty feet eleven inches, together with “ the coals and iron works, carry with them such testi- “ mony that the Romans inhabited that plain, as per- “ suade one to believe that the *stratum* No. 4. proceed- “ ed from the eruption which occasioned the death “ of Pliny.”

Therefore the *strata* N°. 6, 8, and 10, if not those N°. 5, 7, and 9, proceeded from eruptions much ante-  
rior to the foundations of Herculaneum and Pompeia ;  
though the former is said to have been built by Hercules,  
who is supposed to have been cotemporary with Abra-

ham, in the year of the World 2240, near 2000 years prior to their destruction in the 79th year of the Christian æra.

The alternate *strata* of lava and soil have been considered as sufficient data, for proving the antiquity of the world; taking for granted that the quantity of soil contained in each *stratum*, to have been produced by length of time only; not considering that eruptions of sand, ashes or mud, are equally frequent with those of liquid fire, and that such productions become immediately fit for vegetation. Hence the result of such reasonings are rendered fallacious: for although a quantity of soil may accumulate upon a bed of lava in the space of several ages, yet since there are other means whereby lava becomes covered with soil, as in the instances already named, it appears much more probable that the *soil strata*, proceeded from subsequent eruptions, than from length of time. But these observations are rather a digression from the subject. Therefore to return.

Amongst the numerous vestiges of ancient volcanos, I presume there are few more stupendous than those on the northern coast of Ireland, though no visible crater is now remaining between Port Rush Strand and Bally castle eastward; a distance nearly equal 20 miles English, and yet, the whole of that space is one continued mass of lava; and I have been credibly informed that the

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same

same appearances extend many miles from Port Rush towards the west.

The cliffs are indeed truly stupendous, and bear every possible mark of their having been originally liquid fire. The elevation of that at the foot of which the Giants-causeway is situate, we presume cannot be less than five or six hundred feet perpendicular height above the Atlantic Ocean, and yet composed intirely of lava: and the same appearances extend from thence towards the south upwards of twenty miles.

As we purpose giving some further account of these ancient eruptions in Chap. XXIV. together with a Section of the strata, we postpone many other particulars, with respect to these wonderful operations, till we arrive at that part of the work.

We might have enumerated many other instances tending to prove the antiquity and powerful effects of ancient volcanos; but we presume the above may serve to evince the truth of such a conjecture: however, as the subject is a matter of some importance, we shall endeavour to shew, that such operations of nature were consequences necessarily arising from the state and condition of the earth, at those remote periods of time. But previous to that inquiry, it becomes requisite to lay before the reader, sundry phenomena, relative to the cause and effects of earthquakes.

CHAP.

## C H A P. XI.

*Of sundry Phenomena relative to the Cause and Effects  
of Earthquakes.*

1. **P**REVIOUS to an eruption of Vesuvius, the earth trembles, and subterraneous explosions are heard. The sea likewise retires from the adjacent shore till the mountain is burst open, then returns with impetuosity, and overflows its usual boundary. Such undulations of the sea are not uncommon, but frequently precede the eruptions of Vesuvius. Neither are they peculiar to that mountain, but have been notorious in many other parts of the world, as the following instances evidently shew.

2. On the first of November 1755, the æra so fatal to Lisbon, the island of Madeira was violently shook by an earthquake, attended by subterraneous explosions. And about an hour and half after the tremor had ceased, the sea, which was quite calm, retired suddenly some paces from the shore; and returning with a great swell entered the city Funchal; the water rose full fifteen feet above high-water mark, although the tide which ebbs and flows seven feet was then at half ebb: the water immediately receded again, and having fluctuated four

or five times between high and low-water mark, the undulations ceased, and the sea became quite calm as before. In the northern part of this island the undulations were more violent: for the sea retired at first above one hundred paces, and suddenly returning overflowed the shore; destroying or damaging several houses or cottages. Great quantities of fish were left on shore and in the streets, of the village Machico. All this was the effect of one sole undulation; for the sea never flowed afterwards so high as high-water mark, although the fluctuations continued much longer there than at Funchal. Westward the fluctuations were hardly perceptible.

3. The earthquake which destroyed Lisbon on the first of November 1755, was preceded by a rumbling noise, which increased to such a degree as to equal the explosions of the loudest cannon. About an hour after the shocks, the sea was observed from the high grounds to come rushing towards the city like a torrent, though against wind and tide; it rose forty feet higher than was ever known, and suddenly subsided. A ship 50 leagues off at sea received so violent a shock as greatly injured the deck.

4. On the first of November 1755, Cadiz was also violently shook by an earthquake, which threw the inhabitants into great consternation. An hour after, they were

were yet more alarmed at the appearance of a wave eight miles off, coming towards the town, which was at least sixty feet higher than common. The inhabitants began to tremble, and the centinels left their posts. It came against the west part of the town, which is very rocky, and the rocks abated a great deal of its force; but at last it came against the walls, beat in the breast-work, and carried pieces of eight or ten ton weight, forty or fifty yards from the wall. Every one now thought the town would be swallowed up; for altho' this tide was run off, yet with glasses they saw more coming. When the wave was gone, some parts that were deep at low-water were quite dry; for the water returned with the same violence as it came. These waves came in this manner four or five times, but with less force each time.

Another account says, that the inhabitants had scarce begun to recover from their first terror when they saw themselves plunged into new alarms. At ten minutes after eleven they saw rolling towards the city a tide of the sea, which passed over a parapet of sixty feet above the ordinary level of the water. At thirty minutes after eleven came a second tide; and these two were followed by four others of the same kind, at eleven o'clock fifty minutes; twelve o'clock thirty minutes; one o'clock ten minutes, and one o'clock fifty minutes. The tides

con-

continued, with some intervals, till evening. They have ruined 100 toises, or 600 feet of the rampart; part of which, of three toises length and of their intire thickness, was carried by the torrent above fifty paces.

5. The same day and hour the sea came up to the walls of Tangier, a thing never known before, and returned with the same rapidity as it came up, leaving upon the mole a great quantity of sand and fish. These commotions of the sea were repeated eighteen times, and continued till six in the evening, though with less violence than the first time.

6. The same phenomena happened at Arzila, the water came in through one of the city gates very far, with great impetuosity; and a boat was found at the distance of two musket shots from the sea.

7. At Salle the waters came up with great rapidity into the city, and at their return great quantities of fish were found in the streets. Many persons were drowned, and a large number of camels were carried away by the flood.

8. Saffe fared little better; the sea came up as far as the great Mosque, which is within the city, and at a great distance from the sea.

9. Such were the agitations of the sea in foreign parts on the first of November 1755. And the same phenomena were observed on the same day, but in a less degree, at

Plymouth, Portsmouth, Mounts-Bay, Penzance, Swansea, Yarmouth-Haven, Hull, Gainsborough, &c. in England, likewise in Scotland, Ireland, and in Holland. And it was not the sea only which was thus violently agitated, but confined waters in various parts of England and the Continent: namely a Pool at Balborough in Derbyshire, another at Foremark, several at Haynor, &c. Likewise many pieces of water in Kent, Surry, Sussex, Essex, Berkshire, Oxfordshire, &c. At most of these places, the waters were so violently agitated as to overflow their banks.

10. The same fluctuations of waters were observed on several lakes on the Continent: namely the lakes of Geneva, Zurich, Neufchatel in Swisserland, and at Lyons.

11. At Rotterdam the branches in a church were observed to oscillate as a pendulum, and so were the candles in a chandlers shop at Hague.

12. And we are also told, that it is no uncommon thing to see the surface of the earth undulate as waves of the sea, at the time of these dreadful convulsions of nature.

Many other interesting phenomena relative to that tremendous earthquake on the first of November 1755, are recorded in the Philosophical Transactions, vol 49. part 1. but for brevities sake they are omitted.

The

The appearances above related were not peculiar on the first of November 1755, for we have several other notorious instances recorded; namely,

13. In the year 1746, Calloa, a considerable garrison town and sea port in Peru, containing 5000 inhabitants, was violently shook by an earthquake on the 28th of October. And the people had no sooner began to recover from the terror occasioned by the horrid convulsion, but the sea rolled in upon them in mountainous waves, and put a final period to their existence: for they all perished except 200, who were providentially saved on board of ships and fishing boats lying in the harbour. The elevation of this extraordinary tide was such as conveyed ships of burden over the garrison walls, the towers and the town, distant from the sea: one in particular which arrived from Chili the preceding day, was conveyed to the foot of the mountains, and there remained on dry ground. The flood of water flowed over the town with such rapidity, that it tore up the foundations of all the buildings, except those of the two grand gates, and some few parts of the garrison walls, which remain as the only monuments of that dreadful catastrophe. All the other parts of the town were so compleatly erased, and the parts covered by sand and gravel, as totally concealed the appearance of a town having  
ever

ever existed upon the spot of ground where Calloa stood. See Relation of Earthquakes by T. Osborne, 1748.

14. Another instance somewhat similar to the above happened the 29th of September 1535, previous to an eruption near Puzzola, which formed a new mountain three miles circumference, and upwards 1200 feet perpendicular height: for the earth was frequently shook, and the plain lying between the lake Averno, mount Barbaro, and the sea, was raised a little: at the same time the sea which was near the plain retired 200 paces from the shore, and left many fish a prey to the inhabitants of Puzzola. See Sir William Hamilton's Observations on Vesuvius.

The preceding undulations of the sea and other waters, together with the undulatory motion of the earth's surface, and the oscillation of pendulous bodies are phenomena which arise from the expansive force of steam generated in the bowels of the earth, as we shall endeavour to prove hereafter from a series of undeniable facts.

The facts particularly alluded to, are eruptions of boiling water and steam, in various parts of the world, but especially in the vicinity of volcanos. Of which the Rev. Dr. Uno Von Troil, in his Letters on Iceland, has recorded many curious instances, as follow.

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" Near

“ Near Laugervarn, a small lake about a mile in circumference, which is two days journey distant from Helca, I saw the first hot spouting springs, and I must confess that it was one of the most beautiful sights I ever beheld. The morning was uncommonly clear, and the sun had already begun to gild the tops of the neighbouring mountains; it was so perfectly calm, that the lake on which some swans were swimming was as smooth as a looking-glass, and round about arose in eight different places the steam of the hot springs, which lost itself high in the air.

“ Water was spouting from all these springs, but one in particular continually threw up a column from 18 to 24 feet high, and from six to eight feet diameter; the water was extremely hot. A piece of mutton and some salmon trout were almost boiled to pieces in six minutes, and tasted excellently.

“ At Reikuin was another spout of the same sort; the water of which, I was assured, rose to sixty or seventy feet perpendicular height some years ago; but a fall of earth having almost covered the whole opening, it now spouted only between 54 and 60 feet sideways.

“ At Geyser, not far from Skallott, a most extraordinary large spouting fountain is to be seen.

“ One sees here within the circumference of half a mile, or three English miles, 40 or 50 boiling springs  
“ toge-

“ together: in some the water is perfectly clear, in  
“ others thick and clayey; in some, where it passes  
“ through a fine ochre, it is tinged red as scarlet: and  
“ in others, where it flows over a paler clay, it is white  
“ as milk.

“ The water spouts up from some continually, from  
“ others only at intervals. The largest spring, which is  
“ in the middle, particularly engaged our attention the  
“ whole day, from six in the morning till seven at night.  
“ The aperture through which the water rose was 19  
“ feet in diameter: round the top of it is a bason, which  
“ together with the pipe, hath the form of a cauldron;  
“ the margin of the bason is upwards of nine feet one  
“ inch higher than the conduit, and its diameter 56  
“ feet. Here the water does not spout continually, but  
“ only by intervals several times a day: and as I was in-  
“ formed by the people in the neighbourhood, in bad  
“ rainy weather higher than at other times.

“ On the day we were there, the water spouted at  
“ ten different times, from six in the morning till eleven  
“ A. M. each time to the height of between 30 and 60  
“ feet: till then the water had not risen above the mar-  
“ gin of the pipe, but now it began by degrees to fill  
“ the upper bason, and at last it run over. We were  
“ told by the people with us, that the water would soon  
“ spout much higher than it had yet done; which ac-

“ count appearing credible to us, Dr. Lind set up his quadrant, in order to ascertain the elevation thereof with the utmost accuracy. Soon after four o'clock, we observed the earth begun to tremble in three different places, and particularly at the top of a mountain, which was about six hundred yards distant from the mouth of the spring ; we also frequently heard a subterraneous noise like the explosion of cannon ; immediately after which, a column of water spouted from the aperture, which at a great distance divided itself into several parts, and according to the observations made with the quadrant was 92 feet high. Our great surprize at this uncommon force was yet increased, when many stones which we had thrown into the aperture, returned with the spouting water.” The numerous fountains of boiling water which the Doctor observed in his tour through Iceland, together with those in Italy, the Island of St. Miguel, and other volcanic regions of the earth, which either flow continually or by intervals ; and likewise those of steam only, are some of the many phenomena attendant upon subterraneous convulsions ; we shall therefore endeavour to investigate the cause of those appearances in due time. But amongst the various operations of that kind, few are more astonishing, or more instructive than the following, viz.

In

In the years 1631 and 1698, vast torrents of boiling water flowed from the crater of Vesuvius, previous to an eruption of fire. And what was very remarkable, many sorts of calcined sea-shells were found upon the brink of the crater, also in the channel formed by the flood. The former eruption was so considerable that the violence of the flood swept away several towns and villages, and some thousands of inhabitants. And,

In the year 1755, a dreadful torrent of boiling water flowed from the crater of Etna, at the time of an eruption of fire. See Sir William Hamilton's Observations.

The sea shells which accompanied the above eruptions, evidently testify, that a communication had been opened between the two oceans of melted matter and water, insomuch that it seems altogether needless to add any thing more in confirmation of the fact.

The preceding facts relative to eruptions of steam and boiling water we consider as the principal data upon which all the phenomena relative to subterraneous convulsions depend: therefore some attempt to illustrate the mechanical cause thereof may be acceptable to several of our readers.

Let Plate VI. fig. 3. represent the section of a cavernous mountain, situate within the influence of a subterraneous fire. And let A represent a cavern containing water

water with a communication to the external air through the fissure C. And let us also suppose that the cavern A is supplied with water from the caverns B B, which communicate with A by the intermediate fissures represented in the section.

Matters being thus circumstanced, the following effects will necessarily arise: namely, as the water in the cavern A becomes intensely heated, a considerable part thereof will become converted into steam, and having no vent or communication with the external air, but thro' the fissure C, the expansive force of the steam will act on the surface of the water with so much violence, as to occasion a fountain as represented at F. And this fountain will act with more or less force according to the degree of resistance the water meets with: for such as the resistance is, such will be the degree of rarefaction, and the expansive force of the steam, provided the fire is sufficiently near to the water.

Now if the quantity of water received into the cavern A in a given time, is not equal to that discharged, such fountains cannot act perpetually, but by intervals.

But in such cases, wherein the quantities received and discharged are equal, such fountains will flow without intermission; other circumstances being equal.

Again; if the expansive force of steam acts with so much violence as to obstruct the inlets of water from

B B,

B B, the cavern A will become the sooner exhausted, and the time of eruption shortened.

The water being thus totally driven out of the cavern, the steam follows, and soon restores the equilibrium of the expansive force. The force of the steam being thus destroyed, the water descends from the caverns B B, and replenishes the cavern A with cold water.

To the above, and many other similar causes, may be ascribed eruptions of *water, liquid fire, steam*, and all other materials before mentioned ; we may therefore conclude that fire and water are the primary agents concerned in all such operations of nature : for if we suppose melted matter contained in the cavern A, the force of the steam would occasion an eruption of liquid fire ; for the expansive force of the fire would elevate the incumbent weight, and thereby open the communication from A to B B. Hence the water contained in B B would descend into the cavern A, and become converted into steam, and produce the effects before described.

These few hints may serve to convey some idea of the cause whence eruptions of various kinds proceed.

In such instances wherein steam only evacuates continually, there must be a communication between the external air and the surface of the water ; as if it were a caldron of boiling water. Such communications therefore

fore counteract the force of the steam, and prevent its powerful effects, which we have already observed exceeds the force of gunpowder as 14,000 is to 500.

The following instance may serve in some degree to shew the powerful effects of water converted into steam by liquid fire; truths well known to founders conver-  
sant in casting of gold, silver, copper, brass, or iron.  
“ About sixty years ago, a melancholy accident hap-  
“ pened from the casting of brass cannon at Windmill-  
“ hill Moorfields, where many spectators were assem-  
“ bled to see the metal run into the moulds. The heat  
“ of the metal of the first gun drove so much damp  
“ into the mould of the second, which was near it, that  
“ as soon as the metal was let into it, it blew up with  
“ the greatest violence, tearing up the ground some feet  
“ deep, breaking down the furnace, untiring the house,  
“ killing many people on the spot with the steams of  
“ melted metal,” &c. See Cramer’s Art of assaying  
Metals, p. 323.

To the sudden rarefaction and condensation of steam may be ascribed the tremour or shaking of the earth; and also the violent subterraneous explosions which generally precede the eruptions of Etna and Vesuvius.

We may add to the above, that since there are many springs in Iceland, the island of St. Miguel, and many other volcanic regions of the earth, the temperatures of  
which

which vary from each other from  $48^{\circ}$  to  $212^{\circ}$ . May we not thence infer that all tepid and hot springs, which flow in such regions, owe their various temperatures to subterraneous fires?

Now if the above conjectures are true, the presumption is great, that all tepid and hot springs, whether in volcanic, or other region wherein there are no existing volcanos, they nevertheless derive their various degrees of heat to a similar cause.

Hence the springs at Bath, Buxton, and Matlock, may derive their temperatures from subterraneous fires, although there are no existing volcanos in England.

Such are the general phenomena relative to the cause and effects of earthquakes. Whence we may venture to infer, without enumerating the various circumstances, that fire and water are the principal agents employed in all those dreadful operations of nature: namely, the undulations of the sea and other waters before mentioned; together with the undulatory motion of the earth's surface; are all of them wholly owing to the expansive force of steam, generated in the bowels of the earth, by means of subterraneous fire. And we may likewise ascribe all other eruptions, whether of *fire*, *water*, *mud*, *ashes*, *sand*, &c. to the same cause: for although inflammable air, or the damp in mines, occasion violent explosions; yet such explosions are only

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momentary, like the firing of gunpowder; whereas volcanic eruptions explode incessantly with great violence, many weeks, or months together. Hence their operations become so very analogous to the effects of the Elopile, that we are much inclined to attribute their different effects to one and the same cause, as before assigned.

Having premised these matters, we shall endeavour to investigate from the same principles the cause of an universal flood, the origin of mountains, continents, craggy rocks, cliffs, and such other disorderly appearances on the surface and interior parts of the earth. We shall also inquire into the cause of subterraneous convulsions acting more violently in the early ages of the world, than within the last period of three or four thousand years.

CHAP.

## C H A P. XII.

*Of subterraneous Fire, and its Effects on the incumbent Strata, from the first Increment of Heat to its full Maturity. Of the Deluge. Of the Origin of Mountains, Continents, &c. Of the Improbability of a second universal Flood.*

THE numberless instances we find recorded of volcanos and their effects, leave no room to doubt the existence, force, and immensity of subterraneous fires; not only under the bottom of the ocean, but likewise under mountains, continents, &c. in every part of the world hitherto explored. But from what principles they were generated; at what distance of time from the creation of the world; or whether nearer to its center, or its surface, are all of them problems not easily solved, while the phenomena of fire remain in so much obscurity: for as M. Macquer justly observes, in his Elements of Chymistry, vol. 1. p. 7, "an accurate distinction has not yet been made between the phenomena of fire actually existing as a principle in the composition of bodies, and those which it exhibits when existing separately in its natural state: nor have proper and dif-

"in & appellations been assigned to it under those different circumstances :" therefore neither the time, the place, nor the mode in which subterraneous fire was generated, can be truly ascertained, till those clouds of darkness are removed from the science of chymistry.

However, thus much we learn from daily experience : namely, that a certain degree of moisture and dryness are greatly instrumental in the production of fire in the vegetable and mineral kingdoms : and also that those fires commence from the first increment of heat, and gradually increase to their full maturity : therefore, if we may be allowed to reason from the analogy which one part of nature bears to another ; we should thence infer, that subterraneous fires were generated from the same elementary principles, and in like manner gradually increased to maturity.

Having attempted to suggest some idea concerning the original production of subterraneous fire, let us return to the chaotic state of the earth, and endeavour to trace its progressive operations from the first increment of heat, to its full maturity, and mark its effects on the incumbent *strata*.

1. If a certain degree of moisture and dryness were equally as necessary to the production of fire in the bowels of the earth, as in mineral and vegetable kingdoms, we might thence infer, that those parts of the

globe which first began to consolidate, were also the first which began to generate fire: therefore since it appears, Chap. V. that the central part of the earth began to consolidate before the superficial part thereof, the presumption is great, that the former became ignited before the latter.

2. We have also observed, Chap. V. that the chaos began to consolidate by the union of similar particles; whence it appears that an universal sameness prevailed either in the same *stratum*, or in the central part of the earth: therefore it seems highly probable that subterraneous fire was generated universally alike in the same *stratum*, or in the central part of the earth, at one and the same point of time, and gradually increased to its full maturity: as represented Plate I. fig. 1. F F and G, *strata* of liquid fire.

3. It is a truth universally known, that all bodies expand with heat, and that the force or power of that law is unlimited: therefore, as subterraneous fire gradually increased, so in like manner its expansive force increased until it became equal to the incumbent weight. Gravity and expansion being then equally balanced, and the latter continuing to increase every day more and more, became superior to the incumbent weight, and distended the *strata* as a bladder forcibly blown.

4. Now

4. Now if the fire thus generated was surrounded by a shell or crust, of equal thickness and of equal density, its incumbent weight must have been equal: on the contrary, if the surrounding shell or crust was unequally thick, or unequally dense, the incumbent weight must have been unequal.

Therefore, since it appears, Chap. VI. that the Primitive islands were uniform protuberances gradually ascending from the deep, the incumbent weight must have been unequal: for as the specific gravity of stone, sand, or mud, is superior to that of water, we may thence infer that the incumbent weight of the former must have been greater than that of the latter. For example:

Let Plate IV. fig. 3. represent a section of the antediluvian earth; A B C, the Primitive islands; D D the bottom of the ocean; and F F a *stratum* of subterraneous fire. Now the incumbent weight at A B C, being greater than at D D; the bottom of the sea would consequently ascend, by the expansive force of F F, sooner than the islands A B C. The bottom of the sea being thus elevated, the incumbent water would flow towards the less elevated parts to restore the equilibrium of its pressure. Consequently the islands A B C, became more or less deluged, as the bottom of the sea was more or less elevated; and this effect must have been more or less universal, as the fire prevailed more or less universally,

sally, either in the same *stratum*, or in the central part of the earth. Therefore, since it appears, that subterraneous fire operated universally in the same *stratum*, and with the same degree of force; it appears much more probable, that the deluge prevailed universally over the earth, than partially; and more especially when we consider the elevation of the antediluvian hills, according to Chap. VI.

But the tragical scene endeth not with an universal flood, and the destruction of terrestrial animals: for the expansive force of subterraneous fire, still increasing, became superior to the incumbent weight and cohesion of the *strata*, which were then burst, and opened a communication between the two oceans of melted matter and water.

The two elements coming thus into contact, and the latter becoming instantaneously converted into steam, produce an explosion infinitely beyond all human conception; for it has already been observed, that the expansive force of water thus converted into steam, exceeds that of gunpowder in the proportion of 14,000 to 500.

The terraqueous globe being thus burst into millions of fragments, and from a cause apparently seated nearer to its center than its surface, must certainly have been thrown into strange heaps of ruins: for the fragments of the *strata* thus blown up, could not possibly fall together again

again into their primitive order and regularity: therefore an infinite number of subterraneous caverns must have ensued at the distance of many miles, or many hundreds of miles below the bottom of the antediluvian sea.

Now it is easy to conceive, when a body of such an immense magnitude as the earth, which is nearly 8000 miles in diameter, was thus reduced to an heap of ruins, that its incumbent water would immediately descend into the cavernous parts thereof; and by thus approaching so much nearer towards the center, than in its antediluvian state, much of the terrestrial surface became naked and exposed, with all its horrid gulphs, craggy rocks, mountains, and other disorderly appearances.

Thus the primitive state of the earth seems to have been totally metamorphosed by the first convulsion of Nature, at the time of the deluge; its *strata* broken, and thrown into every possible degree of confusion and disorder. Hence, those mighty eminences the Alps, the Andes, the Pyrenean, and all other chains of mountains, were brought from beneath the great deep. Hence, the sea retired from those vast tracts of land, the continents; became fathomless and environed with craggy rocks, cliffs, and impending shores, and its bottom spread over with mountains and vallies like the land.

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It is further to be observed of the horrid effects of this convulsion; namely, that as the Primitive islands were more ponderous and less elevated than the bottom of the sea; may we not thence infer, that the former more immediately subsided into the ocean of melted matter, than the latter; and therefore became the bottom of the postdiluvian sea; and the bottom of the antediluvian sea being more elevated, was converted into the postdiluvian mountains, continents, &c. Such were apparently the consequences arising from the first convolution of nature: and this conjecture is remarkably confirmed by the vast number of fossil shells, and other marine *exuviae*, found imbeded near the tops of mountains, and the interior parts of continents, remote from the sea, in all parts of the world hitherto explored, as represented Chap. VII.

The above phenomena have generally been ascribed to the effects of an universal flood; but we presume such conclusions were too hastily drawn: for it manifestly appears, upon a more strict examination of the various circumstances accompanying these marine bodies; that they were actually generated, lived, and died, in the very beds wherein they are found; and therefore those beds were originally the bottom of the ocean, though in some instances, they are now elevated several miles above

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its level. Thus we find a further agreement between natural phenomena and the laws of Nature.

Hence it appears, that mountains and continents were not primary productions of nature; but of a very distant period of time from the creation of the world. A time wherein the *strata* had acquired their greatest degree of cohesion and firmness. And a time in which the testaceous matter of marine shells was become changed to a stony substance. For I have frequently observed in the fissures of the lime-stone *strata*, fragments of the same shell adhering to each side of the cleft, in the very state in which they were originally broken: insomuch that if the several parts were brought together, they would apparently tally with each other. Whence it is evident that a considerable space of time had elapsed between the chaotic state of the earth and the deluge; which according to the Mosaic account was upwards of 1600 years: but these observations are rather a digression from the subject, and only serve to shew the agreement between revelation and reason: Therefore to return.

It may possibly be alledged, that many of the fossil bodies imbeded near the tops of mountains, are natives of very distant regions of the earth; and therefore could not have existed in the climates where they are now entombed, according to the present constitution of nature:

whence

whence it becomes necessary to shew, that those very climates were originally suitable to the nature of their existence; but this shall be deferred to the following Chapter.

We have indeed already related a series of facts, in Chap. VII. which shew that such fossil bodies were actually generated, and have lived and died in the very beds where in they are found, and consequently were not removed from distant regions of the earth, to their present situation, by a flood, or floods of water, as commonly supposed: therefore let us return to the consideration of sundry phenomena relative to subterraneous convulsions and the deluge of Noah, and likewise to investigate the improbability of a second universal flood commencing in any future age.

According to the Mosaic account, the deluge was attended with sundry phenomena analogous to those which generally accompany subterraneous convulsions: whence it is presumed, that the former and the latter might have arose from one and the same cause.

1st. We have already observed, that previous to an eruption of Vesuvius, the sea retires from the adjacent shore, till the mountain is burst open and begins to discharge its fiery contents, then returns with impetuosity, and overflows its boundary.

Such operations of nature seem to imply, that mount Vesuvius and parts adjacent were actually elevated above their natural position, previous to the eruption; and subsided again to their former level as soon as the steam found vent. And this conjecture is apparently confirmed by the subterraneous explosions which commonly precede the eruptions: for the sudden conversion of water into steam by melted matter, we have already observed, produces the most violent effects.

2d. The return of the sea towards the shore, immediately after the mountain is burst open, evidently shews that the mountain previous to that event subsides to its former level, and therefore the waters return to restore the equilibrium of its pressure. Hence we infer that the fluctuations of the sea, which accompany subterraneous convulsions, wholly arise from that cause: for when the land is more elevated by the force of steam than the bottom of the ocean, the water retires from the shore towards the less elevated parts, and leaves its bottom dry: and when the bottom of the sea is more elevated by the same cause than the land, the water runs in mountainous waves towards the land, and deluges the shores. Which seems to have been the cause of those dreadful floods at Lisbon and Cadiz, in the year 1755; and also that which destroyed Calloa in the year 1746. This idea seems to be confirmed by the

the space of time elapsed between the convulsion and the arrival of the wave at the above cities, an hour and half after the shocks had ceased: and their being observed at some considerable distance rolling towards the towns, points out in some degree the direction and situation of the elevated part of the Ocean, from whence the floods proceeded.

3d. As many parts of Europe and Africa were affected in the above manner, but in a less degree, on the first of November 1755; we may thence infer the powerful and extensive effects of subterraneous convulsions.

Having considered subterraneous fire and water as the principal agents concerned in these stupendous operations of nature; it becomes requisite to observe, that steam is susceptible of a considerable degree of condensation by a small degree of cold: therefore the same degree of expansive force can only exist during the same degree of heat. Whence it is evident, that the undulations of the sea and confined waters, can extend no further than subterraneous fire extends: consequently, as the undulations of the sea and confined waters were observed throughout Europe, and many parts of Africa, on the first of November 1755, we may thence infer that subterraneous fire extended so far at least.

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It now remains to consider, in a more particular manner, the cause of these undulations.

When the *strata* incumbent on the melted matter becomes elevated and burst open, so as to admit of sea water falling upon the melted matter, a sudden rarefaction of water into steam ensues, which may be productive of a further admission of cold water. Hence arise sudden condensations and rarefactions of steam, and consequently violent tremours or shakings of the earth.

The impending roof being separated from the liquid fire by steam thus generated, permits the vapours to extend laterally in all directions from the original source; whereby the *strata* becomes progressively elevated and the parts raised, more so than those in the act of separation.

Hence the horizontal position of the earth's surface becomes altered to that of an inclined plane: consequently, buildings erected in perpendicular direction, acquire a reclining posture; and the waters of the sea, lakes and ponds, receive an undulatory motion, with as much certainty as that contained in a vessel suddenly elevated on one side more than on the other. Water being thus agitated by one impeding force, continues undulating till its acquired momentum is overcome by the resistance of some external cause.

Such however, are the phenomena, and such the principles from whence we presume they arise: we therefore

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consider them as quite analogous to the principles applied in the investigation of the deluge; and as we shall have occasion to enlarge upon this subject in a future part of the work, we defer for the present adding any more instances in favour of the doctrines above advanced.

To what has been said, we may add a few observations on some peculiar properties inherent in matter, which greatly contribute to produce the above supposed effects.

The Reverend Mr. Michell, in his excellent Treatise on Earthquakes, has set these qualities in a very conspicuous light.

“ The compressibility and elasticity of the earth,” says the learned author, “ are qualities which do not “ shew themselves in any great degree in common instances, and therefore are not commonly attended to. On this account it is that few people are aware “ of the great extent of them, or the effects that may “ arise from them, where exceeding large quantities of “ matter are concerned, and where the compressive force “ is commonly great.

“ The compressibility and elasticity of the earth may “ be collected in some measure from the vibration of “ the walls of houses, occasioned by the passing of carriages in the streets next to them. Another instance, “ to the same purpose, may be taken from the vibration “ of steeples, occasioned by the ringing of bells, or “ gusts

“ gusts of wind: not only spires are moved very considerably by this means, but even strong towers will sometimes be made to vibrate several inches, without any disjointing of the mortar, or rubbing the stones against one another. Now it is manifest, that this could not happen without a considerable degree of compressibility and elasticity in the materials of which they are composed.”

Hence we may infer, that if so short a length of stone as that of a steeple, visibly bends, by so small a degree of force as the ringing of bells, or a blast of wind; we may thence conclude, that the *strata*, in their primitive state might become considerably distended by an unlimited force: since it appears by a fair deduction, that if a globe 80 inches diameter, suffered a degree of expansion equal to the thickness of a human hair; the same proportion, by analogy, would have raised the bottom of the ocean one fourth of a mile perpendicular height above its former level, and thereby have occasioned an universal flood; since we cannot suppose, that the elevation of the Primitive islands were more than forty or fifty feet, compared to those formed in the sea by the flux and reflux of the water, according to Chap. VI.

Having concluded our observations on the deluge, the origin of mountains, continents, and all other irregular appearances, on the surface and interior parts of the

earth; let us inquire into the improbability of a second universal flood, and likewise into the cause of subterraneous convulsions having produced more violent effects in the early ages of the world, than they have done since the commencement of records.

It will readily be granted that the *strata* which compose the earth, had originally an uniform, concentric arrangement; and likewise, that they had acquired their greatest degree of cohesion and firmness before they were burst and thrown into heaps of confusion: whence it is evident, that a much greater degree of force was requisite to overcome the incumbent weight and cohesion of the *strata*, in that firm uniform state, than can be requisite to separate the fractured parts thereof; consequently the same degree of force can never accumulate in any future age while so many fissures and volcanos daily give vent to the expansive vapours, and thereby counteract their violent effects.

Hence it appears, that as the expansive force of subterraneous steam in the postdiluvian world, is so much inferior to that accumulated in the antediluvian state of nature; and the mountains of the former, being so much more elevated than the hills of the latter; the presumption is great, that the earth can never become deluged a second time from a similar cause, nor its *strata* suffer the same degree of violence.

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But after all our attempts to inquire into these difficult and immense operations of nature, the magnitude of the earth so much exceeds the bounds of human conception, that we can form no adequate idea of its bulk, nor of the relation which the mountains, and other inequalities, bear to its diameter: therefore let us reduce this great globe to such a scale as we can distinctly view and comprehend.

It is generally allowed that the earth is nearly 8000 miles diameter: therefore let us measure it by a scale equal 80 inches; since one inch will then bear the same proportion to a globe 80 inches diameter, as 100 miles does to the diameter of the earth.

Hence one-tenth of an inch bears the same proportion to a globe 80 inches diameter, as a mountain 10 miles perpendicular height, does to the earth.

Again, as one-hundredth part of an inch is to a globe 80 inches diameter; so is a mountain one mile perpendicular height to the earth.

And as the thickness of a human hair, is nearly equal one four-hundredth part of an inch, it will nearly bear the same proportion to a globe 80 inches diameter, as a mountain one-fourth of a mile perpendicular height, does to the earth.

These proportions being duly considered, we shall be enabled thereby to form some comparative idea of the relation

lation between the antediluvian hills and the postdiluvian mountains: some of the latter we know, from geometrical and barometrical mensurations, are upwards of three geographical miles, or 19,026 feet above the level of the sea. (See Ulloa's Voyage, vol. 1. p. 442.) Whereas we cannot suppose the former were more than 40 or 50 feet perpendicular height above it, since they were formed by the action of the tides as sand banks are formed in the ocean.

The inequalities on the earth's surface, before and after the flood, being thus measured by a scale familiar to our conception, we may form some general idea of the great alterations which this globe has undergone, and also of the improbability of a second universal flood ever arising from a similar cause.

In the former part of this work we have pointed out some instances, wherein the result of our reasoning manifestly coincides with revelation; therefore though we have assigned a different cause for an universal flood, than that in the scripture account; yet in some respects the two accounts are so perfectly analogous, that I am inclined to consider the Mosaic account of the flood as judiciously accommodated to vulgar minds, rather than to those of men accustomed to physical investigations, and as such, of more general utility.

In the scripture account we are told, that "the fountains of the great deep were broken up, and the windows of heaven were opened, and the rain was upon the earth forty days and forty nights." And in the book of nature we find, that the earth is frequently burst open and deluges the adjacent countries, together with the destruction of some thousands of inhabitants: and also that these convulsions of nature are accompanied with incessant rains. Whence it is presumed there is a considerable analogy between the facts recorded in revelation, and the operations of nature. In short, the analogy is so extremely obvious, that we think it needless to add any thing more to illustrate the subject.

Being fully persuaded that the preceding attempts to investigate an universal flood, the origin of mountains, continents, &c. have some foundation in nature and truth, I am induced thereby to offer the following historical accounts to the consideration of the reader, although they have generally been looked upon as fabulous; presuming they are attended with some natural circumstances not before considered. The stories are recorded in the posthumous work of the learned Doctor Robert Hooke, p. 439, 441, 443, to the following effect.

1. It is recorded by Fulgosas, that in the year 1462, as some men were working a mine, near Bern in Switzerland,

zerland, they found an old ship 100 fathoms deep in the earth, built as ours are, with anchors of iron and sails of linen, with the carcases of 40 men.

2. Pairre Naxis, relates a like history of another such ship having been found under a very high mountain.

3. In like manner the Jesuite Eusebius Neucombergus, in his second chapter of the fifth book of Natural History says, that near the Port of Lima in Peru, as the people were working a gold mine, those who followed the *vein*, found an old ship, on which were many characters very different from ours.

4. Strabo also relates, in his first book, that the wrecks of ships have been found at the distance of 3000 furlongs, or 375 miles from the sea. Thus far Dr. Hooke.

5. Dr. Plott, in his Natural History of Staffordshire, Chap. VIII, relates a story somewhat similar to the former; namely, that the mast of a ship with a pulley hanging to it, was found in one of the Greenland mountains.

Such are the accounts recorded by several authors, relative to ships having been found in the bowels of the earth remote from the sea, and which have hitherto appeared highly fabulous: but we hope the following observations will free them from the imputation of fable.

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First, The stories do not seem to have been invented, either in favour, or in opposition, to any particular system, but simply related from people who were eye-witnesses of the several phenomena.

Secondly, Two of the ships are expressly said to have been found in *mines*, or *mineral veins*.

Hence it is necessary to observe, that the generality of mineral veins, are no other than fissures in the *strata* containing mineral substances, which in all probability were originally produced by subterraneous convulsions at the time of the deluge, when the waters prevailed universally over the earth, and when the *strata* were burst to the depth of many miles, and when the incumbent waters descended into the gulfs thereof, and left much of the terrestrial surface naked and exposed, with all its horrid gulfs, &c.

Now if ships were in use at the time of that dreadful catastrophe, and floating immediately over these gulfs at the time they were opened, they must necessarily have descended therein, and have remained in the bowels of the earth, and probably at the distance of many hundred miles from the sea, since the bottom of the sea was converted into mountains and continents. Such effects are not however repugnant to the operations of nature: for we have had several recent instances somewhat similar, and particularly at Port-Royal in Jamaica, in the year 1692.

At which æra, not only many houses were swallowed up, but also several ships and sloops suffered the same fate, insomuch that only some parts of their masts appeared above water. See Lowth. Abr. Phil. Trans. vol. 2. p. 411, 415. May we not thence infer, that the same cause might have produced similar effects either at the time of the deluge, or in subsequent ages, if ships were in use? And what still renders this conjecture the more probable is, that of subterraneous convulsions having produced much more violent effects in the early ages of the world, than they have done within the last period of three or four thousand years.

These matters being duly considered, I presume they will not only free the stories above related from the imputation of fable, but will also induce the reader to admit them as collateral evidence relative to the origin of mountains, continents, &c. and likewise as testimonies of the great antiquity of naval architecture, navigation, and sciences in general, as we have already conjectured, Chapter II.

CHAP.

## C H A P. XIII.

*Of the Temperature of the Air, and Seasons of the Year,  
before and after the Flood.*

**I**N the preceding chapter we have endeavoured to prove from a series of undeniable facts, that the antediluvian world was universally deluged: likewise the improbability of a second universal flood ever arising from a similar cause in any future age: and also that mountains and continents were not primary productions of nature, but were raised from beneath the deep at the time of the deluge whilst the waters prevailed over the earth.

Such were apparently the great alterations and changes which the earth underwent at the time of that dreadful convulsion of nature.

Let us therefore inquire what effects might ensue in the temperature of the air and seasons of the year from the production of mountains and continents at the time of the deluge: for as the Primitive islands were apparently formed by the action of the tides, as sand-banks are formed in the sea, we cannot reasonably estimate their elevation at more than 40 or 50 feet perpendicular height:

height: whereas some of the postdiluvian mountains have been found by actual mensuration not less than 19,026. Whence it is presumed that the constitution of the atmosphere in the postdiluvian world, might undergo an equal change with the different inequalities on the superficial parts of the earth, before and after the flood.

The above inquiry happily dependeth on such phenomena as are commonly known, though not ascertained with so much accuracy as the importance of the subject requires. Namely, that of thermometrical observations on the temperature of the air by sea and land in all parts of the world. However, since mankind are accommodated with proper instruments for that purpose, I have no doubt, but that such observations will be made in due time, as will give the subject a lasting foundation. The following are such as we have been able to collect for the present towards obtaining the end proposed.

1. It is a general observation, that the interior parts of continents are subject to greater extremes of heat and cold, than the exterior, or the coasts of the sea. First, from the continuance of frost and snow, in the former, at a time when it will not lie on or near the coast of the latter. Secondly, from the plants and fruits of the earth being burnt up within land, when there is an agreeable verdure on the shore.

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2. Hence Cornwall, being a peninsula, is less subject to extremes of heat and cold, and to sudden transitions from one extreme to another, than the central parts of England : " vegetables flourish all winter in the former, " which can only be preserved in the latter by artificial " means : nor have they seldom any frost till after Christ- " mas, but a temperate air, and an exceeding fine ver- " dure on the ground ; their spring seasons are indeed colder, and last longer than in the central parts of Eng- land." Dr. Borlace's Nat. Hist. of Cornwall.

3. " The temperature of the air in Norway differs " more than a stranger could well imagine in the same " parallel of latitude ; for on the east side of Norway " the winter's cold generally sets in about the middle of " October, and continues to the middle of April ; the " waters are frozen to a thick ice, and the mountains " and vallies are covered with snow.

4. " Yet when the winter rages with so much seve- " rity on the eastern side of Norway, the lakes and bays " are open on the western side, though in the same pa- " rallel of latitude ; the air, indeed, is misty and cloudy, " but frost is seldom known to last longer than a fort- " night or three weeks.

5. " In the center of Germany, which is 200 leagues " nearer the line, winters are more severe than in the " diocese of Bergin, where the inhabitants often won-

“ der to read in the public papers, of frost and snow in  
“ Poland and Germany, when they have no such wea-  
“ ther there.

6. “ The harbours of Amsterdam, Hamburg, Co-  
“ penhagen and Lubeck, are frozen ten times oftener  
“ than the harbour of Bergin ; and when the harbour  
“ of Bergin is frozen, the Seine at Paris is generally in  
“ the same condition.

7. “ It seldom happens that the bays and creeks are  
“ frozen over in Norway, except those that run far up  
“ the country. In the other parts of the western coast,  
“ hard winters, or lasting frosts, are seldom heard of.”  
Pontopidion's Nat. Hist. Norway.

8. “ It is well known to all who sail northward, as  
“ far as lat. 77. that the coasts are frozen up many  
“ leagues, when the open sea is not so ; no not even  
“ under the pole.”

9. “ Some years since, a company of merchants at  
“ Amsterdam, who advanced 100 leagues above Nova  
“ Zembla, towards the east, discovered a sea free from  
ice, and very convenient for navigation.” Lowthorp's  
Abridg. Phil. Trans. vol. iii. p. 611.

10. We are well assured, by the testimony of Capt.  
Baffin, that the northern parts of Greenland are less in-  
cumbered with ice than the southern ; and that he found  
no ice in Baffin's Bay, though in lat. 74 ; and, as he

advanced still further north, he found the air more soft and temperate; very different from what he had felt in Davis's Straights, and on the south of Greenland.

11. And it appears, in the journals of Frederick Martin of Hamburgh, a man of good credit, that when Spitsbergen is doubled three or four degrees, to the north, no more ice is to be seen.

12. Capt. Wood likewise observes, in a paper which he published before he performed his voyage, that two Dutch ships had proceeded northward, as far as latitude  $89^{\circ}$ , and there found the sea free from ice, and of an unfathomable depth; as appears by four of their journals, which though separately kept, concur in those circumstances.

12. Capt. Wood farther adds, that a Dutchman of great veracity had assured him, that he had passed even under the pole, and found the weather as warm as at Amsterdam.

13. Other navigators have also observed, that the weather was warm in lat.  $88^{\circ}$  north, and the sea perfectly free from ice, and rolling like the Bay of Biscay. See the Hon. Daines Barrington's Observations on the Probability of reaching the North Pole, p. 11.

14. The same author, p. 21, mentions another ship having sailed within half a degree of the pole; and many other interesting accounts of navigators having advanced

vanced to high latitudes: insomuch that no doubt can remain of the high seas under the pole being open, at all times, and fit for navigation, though much incumbered with ice in lower latitudes. The cause of these phenomena will be considered in its due place.

15. The continent of North America, we are told, is subject to great extremes of heat and cold, and to sudden transitions from one extreme to another.

16. That in South Carolina, though situate almost twenty degrees more south than London, frost is sometimes very intense; at others they have a degree of heat equal to 100° Farenheit's scale.

17. "At Cape Henry, lat. 36° 30' north, the temperature of the air and seasons are much governed by the winds in Virginia, both as to heat and cold, moisture and dryness, the variations of which are very remarkable; there being often great and sudden changes. The north and north-west winds are very nitrous and piercing, cold and clear, or else stormy; the south-east and south, hazy and sultry hot. Their winter is a fine clear air, mild and dry, which renders it very pleasant; their frosts are short, but sometimes so very sharp, as to freeze the rivers over, though three miles broad; nay, even the Potomack river, where it is near nine miles broad." Lowthorp's Abr. Phil. Trans. vol. iii. p. 576.

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18. We are also told, that their lakes and rivers are generally frozen over early in the winter, and remain in the same state till late in the spring, though situate many degrees more south than the Land's-end of England; and that at Quebec the mercury will frequently mark  $100^{\circ}$  at one time, and  $40^{\circ}$  or  $50^{\circ}$  below the freezing point at another.

19. In Maryland the temperature of the air has been truly ascertained by Fahrenheit's thermometer. The following table shews the result of four years observations, *viz.* 1754, 1755, 1756, 1757. See Philos. Trans. vol. li. 62, 82. To which is added a comparative view of the climate of London, for the same years; shewing the greatest degree of heat and cold in each month. See Gentleman's Mag. for the above years.

The first column contains the months; the second, marked H, shews the highest state of the mercury; L, the lowest; and V, the variation in each month. For example: London, January 1754, the highest state of the mercury was  $48^{\circ}$ , the lowest  $25^{\circ}$ , the variation  $23^{\circ}$ ; Maryland,  $61^{\circ}$  the highest,  $21^{\circ}$  the lowest, and  $40^{\circ}$  the variation.

LON-

Mon.	L O N D O N. Lat. $51^{\circ} 30'$			M A R Y L A N D. Lat. $39^{\circ}$																				
	1754	1755	1756	1757	1754	1755	1756	1757	1754	1755	1756	1757												
	H	L	V	H	L	V	H	L	V	H	L	V												
Jan.	48	25	24	45	27	18	49	39	10	44	28	16	61	21	40	69	23	46	73	15	58	65	10	55
Feb.	48	25	23	44	31	13	50	32	18	52	31	21	61	10	31	64	14	50	70	27	43	67	8	59
Mar.	46	29	17	51	32	19	54	35	19	54	33	21	71	27	44	79	24	55	-	-	-	65	30	35
Apr.	54	32	22	65	42	23	53	32	21	61	30	31	78	42	31	80	40	40	83	29	54	65	30	35
May	-	-	-	64	45	19	64	37	27	64	45	19	85	45	40	87	47	40	81	48	33	88	+8	40
June	-	-	-	71	61	16	70	48	22	67	56	11	87	56	31	90	70	20	86	44	42	80	72	2
July	-	-	-	70	55	15	68	51	17	77	59	18	8	61	26	93	60	33	93	69	24	90	64	26
Aug.	-	-	-	66	52	14	65	-	-	76	4	22	88	62	26	90	61	29	93	68	25	90	67	23
Sept.	64	43	21	67	48	19	64	50	14	61	53	8	80	73	7	93	45	48	92	60	32	88	47	41
Oct.	56	39	17	65	41	24	62	30	32	56	42	14	80	34	46	75	36	39	90	29	61	67	43	24
Nov.	49	27	22	55	28	27	54	31	23	55	38	17	67	23	44	65	20	45	73	27	46	65	33	32
Dec.	-	-	-	50	34	16	51	31	20	51	35	16	60	23	37	71	15	56	63	13	50	68	28	40

By thus comparing the climate of London with that of Maryland, it appears, that the latter is subject to much greater extremes of heat and cold than the former.

Although Fahrenheit's thermometer is generally known, it may not be improper to name the relative degrees of heat and cold referred to in the above table. For example:  $32^{\circ}$  marks the first increment of freez-

freezing;  $48^{\circ}$  the temperature of common spring water;  $68^{\circ}$  that of Matlock Bath;  $82^{\circ}$  Buxton Bath;  $96^{\circ}$  vital heat;  $114^{\circ}$  King's Bath, at Bath;  $212^{\circ}$  the heat of boiling water; and likewise, that cold increases in the same proportion below the freezing point.

The following table is a farther testimony, that the continent of America is not only subject to great extremes of heat and cold; but likewise to great and sudden changes from one extreme to another.

The first column contains the year, month, and day. Those N° 1, 2, 3, shew the state of the thermometer, in the morning, noon, and evening. The column D, shews the variation of temperature each day; and M, the monthly variation.

Those numbers marked thus — denote the number of degrees below 0. For example: January 3, the number —24, signifies that the mercury was  $24^{\circ}$  below 0, or  $56^{\circ}$  below the freezing point.

*Obser-*

*OBSERVATIONS on the Temperature of the Air, at Prince of Wales Fort, on the north west coast of Hudson's Bay, in Lat. 58° 47' N. in the Years 1768 and 1769, by Mr. William Wales and Mr. Joseph Dymond.*

1768	1	2	3	D	M	1769	1	2	3	D	M	1769	1	2	3	D	M
Sep. 10	41	41	41	0		Jan. 3	—24	—16	8			May 3	45	32	37	13	
14	45	41	38	7		6	—29	31	35	64		6	50	35	39	15	
16	37	34	3			9	—19	—21	—30	11		9	49	45	26	23	
18	38	33	5			12	—28	—15	—17	13		12	25	24	22	2	
20	45	38	7	32		15	—21	—28	—31	10	71	15	40	27	32	13	32
22	60	63	65	5		18	—32	—36	—30	6		18	54	32	44	22	
24	54	50	46	8		21	—29	—36	—36	7		24	43	47	33	14	
28	46	46	44	2		24	—28	—31	—19	12		27	48	36	34	14	
30	47	50	35	15		27	—20	—31	—34	14		30	49	34	37	15	
Oct. 3	36	34	29	7		Feb. 2	—1	—21	—30	19		June 3	60	42	18		
6	35	34	29	6		4	0	—19	—20	20		6	45	36	38	9	
9	35	37	34	3		6	—16	—23	—24	8		9	50	44	40	10	
12	32	31	33	2		9	15	12	12	3		12	41	39	40	2	
15	36	31	17	19	24	12	—3	—21	—26	23		15	46	41	5	28	
18	33	32	32	1		15	3	—2	—11	14	52	18	50	44	35	15	
21	36	36	27	9		18	4	—19	—18	15		21	63	57	41	22	
24	20	21	13	8		21	6	—20	—32	38		24	49	57	61	12	
27	28	27	14	14		24	—10	—29	—37	27		27	60	50	55	10	
30	22	18	20	4		28	9	—12	—30	21		30	60	49	44	16	
Nov. 3	32	24	18	14		Mar. 3	—13	—15	—30	17		July 3	76	80	74	6	
6	5	—10	7	15		6	—19	—30	—41	22		6	54	46	49	8	
9	—3	3	4	7		9	—11	—11	6	17		9	51	50	61	11	
12	15	12	18	6		12	0	5	—23	23		12	85	48	52	37	
15	3	6	5	11	48	15	—16	—21	—25	9	81	15	55	50	49	6	39
18	—7	—14	—15	8		18	1	1	7	6		18	66	62	52	14	
21	10	7	3	7		21	4	—8	—11	15		21	58	62	54	8	
24	7	1	7	14		24	—5	—21	—23	18		24	54	59	56	8	
27	—15	—16	—16	1		27	40	24	—11	29		27	59	53	6		
30	—10	9	4	14		30	20	7	8	13		30	55	65	54	11	
Dec. 3	—6	—10	—17	11		Apr. 3	7	—7	—12	19		Aug. 3	50	54	48	6	
6	—16	—22	—26	10		6	20	2	0	22		6	68	54	52	16	
9	—9	—13	—20	11		9	33	22	11	22		9	60	52	58	8	
12	—39	—39	—22	17		12	19	15	12	7		12	61	53	52	9	
15	—22	—27	—15	12	65	15	29	9	5	24	68	15	56	57	48	9	24
18	—8	—10	—16	8		18	34	26	20	14		18	40	43	44	4	
21	14	17	13	4		21	38	17	20	21		21	57	51	6		
24	17	26	—24	50		24	36	26	26	10		24	51	48	3		
27	11	15	6	21		27	48	34	24	22		27	53	49	44	9	
30	5	12	18	23		30	36	32	32	7		30					

The preceding observations evidently shew that the continent of North America is subject to much greater extremes of heat and cold than England ; and likewise to more sudden transitions from one extreme to another : therefore, let us endeavour to compare the temperature of the air in Great Britain with that upon islands of less magnitude, and those with the temperature of the air at sea.

1. It is well known, that in the south-west parts of Ireland, myrtles grow in common with other shrubs, and that they even arrive to the amazing height of ten or twelve feet ; though in most parts of England they are only preserved by art, and perhaps, in no part of it, flourish with the same degree of luxuriancy : whence it appears, that the climate of Ireland is more temperate than that of England.

2. The Orkneys, we are told, are more subject to rain than snow or frost, which do not continue so long as in other parts of Scotland.

3. In Farro Island, lat.  $62^{\circ}$  north, frost seldom continues longer than a month, and is withal so moderate, that ice is never seen in an open bay ; nor are sheep or oxen ever brought under cover.

4. Madeira, situate lat.  $32^{\circ}$  north, is not subject to greater degrees of heat than England.

5. In

5. In Goree, lat.  $15^{\circ}$  north, they breathe a cool and temperate air, almost the whole year round, being continually refreshed by land and sea breezes. See Aden-son's Voyage, p. 104.

6. St. Helena, situate lat.  $16^{\circ}$  south, is also extremely temperate, as appears by the observations of the Rev. Dr. Maskelyne, Astronomer Royal, made in the year 1761. See Philos. Transact. p. 440.

*Observations on the Temperature of the Air at  
ST. HELENA, 1761.*

April	25	73°		May	1	72°
	26	73			2	72
	27	73			3	71
	28	73			4	71
	29	73			5	70
	30	72			6	70
					7	72
					8	72

7. And according to the observations of our late navigators, most of the islands in the southern hemisphere, enjoy a degree of temperature and fertility much superior to the climate of England.

Though it appears from various circumstances, that islands of less magnitude than Great Britain are less sub-

ject to extremes of heat and cold; yet the phenomena of land and sea breezes, which generally accompany those within or near the tropicks, seems to shew that they are subject to greater tranfitions from heat to cold, than the atmosphere at sea: therefore, since the temperature of the air on islands has not been generally ascertained, it becomes necessary to investigate the cause of those alternate breezes from sea and land, as the only testimony to prove that the temperature of the former is more equable than that of the latter. The phenomena are as follows:

In the middle, or hottest part of the day, the sea breeze blows towards the land, in every possible direction: and in the middle, or coldest part of the night, the land breeze blows towards the sea, in every possible direction. Thus they alternately succeed each other, as constantly as night and day.

These singular phenomena seems to arise from the following unalterable laws of nature: namely, those properties of the air whereby it becomes subject to rarefaction by heat and condensation by cold; and in part to the situation of the islands within the torrid zone, where days and nights are nearly equal all time of the year.

To the above, we may add the following qualities of matter. viz. That water is a conductor of heat or cold: and

and that the earth is a much inferior conducting substance. Hence heat and cold do not accumulate on the surface of water, but in a short time its whole mass becomes equally hot or equally cold: and the earth being a non conducting substance, heat or cold accumulates upon its surface, and does not become diffused to any considerable depth.

Hence it comes to pass, that the surface of land under the torrid zone, acquires much more heat than the surface of the sea; consequently the atmosphere of the former becomes more rarefied than that of the latter, and rendered thereby specifically lighter than the air at sea. The equilibrium of pressure being thus destroyed, the air upon the island ascends by the superior weight of the air at sea, which moves in all directions towards the central parts of the island, and with more or less velocity according to the different densities of the two mediums, and thus produces a sea breeze. When night approaches, the sun's heat abates, until the atmosphere at land becomes equally dense with that at sea. The equilibrium of pressure being thus restored, the sea breeze totally ceases and remains quiescent; till cold, increasing by the absence of the sun, accumulates on the surface of the islands, and condenses their incumbent atmospheres more than that at sea: for water being a conductor, cold becomes equally diffused throughout its whole mass, and

therefore cannot accumulate on its surface. The land atmosphere being thus rendered specifically heavier than the air at sea, begins to descend by its superior weight, and then blows in all directions towards the sea ; till the sun returns, and restores the two atmospheres to an equal density : the air then becomes stagnant, and remains in a quiescent state, till it is again rarefied by the accumulation of heat, as before.

That the sea has a property of conducting or diffusing heat and cold throughout its whole mass, plainly appears from the experiments made on its temperature by Mr. Bayley, on board his Majesty's sloop Adventure, in her voyage towards the south. The result was as follows :

	External air	72 $\frac{1}{2}$
1772, Aug. 27.	The sea near its surface	70
	At the depth of 80 fathoms	68
Dec. 27.	External air	31 $\frac{1}{2}$
	The sea near its surface	32
	At the depth of 160 fathoms	33 $\frac{1}{2}$
1773, Aug. 28.	External air	64
	The sea near its surface	59
	At the depth of 140 fathoms	56 $\frac{1}{2}$

That land is not a conductor of heat and cold appears from the uniform temperature of springs near the surface of the earth : for water contained in wells not more than ten or twenty yards deep, varies nothing in its temperature, winter nor summer ; being constantly about 48 or 50 degrees.

Hence

Hence it appears that land and sea breezes wholly arise from an alternate rarefaction and condensation of the air on islands; and to a more constant uniform temperature of the air at sea, both night and day.

Such are the apparent causes of the land and sea breezes, which accompany all the islands situate within the torrid zone. Therefore the temperature of the air at sea, is more constant and uniform than upon islands; and this conclusion is abundantly confirmed by the observations contained in the following table.

*Obser-*

*Observations on the Temperature of the Air at Sea, on board his Majesty's Sloop Adventure, in her Voyage on Discoveries towards the South. By Mr. William Bayley. The First Column contains the Year, Month, and Day. The second shews the Latitude. The Columns 1, 2, 3, shew the state of the Thermometer, in the Morning, Noon, and Evening; and D, the Variation of Temperature each Day.*

1772	Lat. N.	1	2	3	D	1772	Lat. S.	1	2	3	D	1773	Lat. S.	1	2	3	D
July 17	46° 26' 67" 68' 66" 2					Nov. 20	- - -	-	-	-	-	Mar. 31	46° 18' 53' 53' 52' 1				
18 46	46° 68' 69" 65' 4					21	- - -	-	-	-	-	6	43° 57' 53' 52' 51' 2				
19 45	20° 65' 64" 65' 1					22	33° 55° -	60° -	-	-	-	9	43° 40' 55' 51' 57' 3				
20 43	56° 65' 67" 64' 3					23	34° 34° -	65° -	-	-	-	12		57° 58' 52' 6			
22 43	37° 65' 66" 65' 1					24	35° 20° -	63° -	-	-	-	15	43° 20° 56' 56' 51' 5				
24 40	36° 66' 67" 67' 1					25	37° 14° -	63° 62° 1				18		57° 58' 52' 6			
26 35	31° 70° 72° 69° 3					26	39° 06° 2	69° 60° 9				19	40° 22° 53' 54' 52' 2				
28 32	48° 72° 74° 73° 2					27	40° 15° 52° 53° 2					21	39° 16° 58° 59° 57° 2				
	Madeira.					28	40° 55° 53° 59° 52° 7					24	38° 58° 57° 51° 53° 5				
30 -	- - -	73° 76° 74° 3				29	42° 8° 52° 52° 53° 1					27	40° 14° 61° 61° 60° 1				
31 32	33° 74° 75° 74° 1					30	42° 26° 52° 55° 51° 3					31	41° 14° 62° 62° 64° 2				
Aug. 3	29° 43° 72° 73° 72° 1					Dec. 3	44° 27° 47° 48° 46° 2					Apr. 3	10° 40° 52° 63° 60° 3				
6 26	6° 73° 73° 72° 1					6	48° 23° 36° 36° 35° 1					6	11° 41° 46° 63° 61° 57° 6				
9 0	28° 74° 75° 74° 1					9	49° 40° 33° 34° 35° 2					Q.	Charlotte's Sound.				
12 15	71° 77° 79° 78° 2					12	32° 34° 32° 2					9	- - -	54° 61° 55° 7			
15 13	48° 79° 81° 79° 2					15	55° 22° 28° 31° 3C 3					12	- - -	54° 62° 55° 8			
18 11	25° 77° 81° 77° 4					18	54° 59° 31° 31° 3C 1					15	- - -	52° 57° 54° 5			
21 8	41° 79° 78° 77° 2					21	54° 73° 32° 34° 31° 3					18	- - -	- - -			
24 6	24° 79° 79° 78° 1					24	56° 29° 32° 34° 32° 2					21	- - -	53° 59° 59° 6			
27 4	13° 78° 78° 78° 0					27	58° 21° 32° 35° 32° 3					24	- - -	49° 54° 50° 5			
30 2	40° 78° 78° 77° 1					30	59° 22° 32° 34° 32° 2					27	- - -	44° 57° 54° 13			
31 2	40° 78° 78° 78° 0					31	59° 55° 30° 33° 32° 3					30	- - -	50° 54° 51° 4			
Sept. 3	1° 17° 77° 77° 77° C					1773						May 1	- - -	56° 59° 54° 5			
6 0	36° 17° 77° 77° 76° 1					Jan. 3	59° 23° 31° 32° 31° 1					3	- - -	17° 57° 45° 12			
	Latitude South.					6	59° 59° 33° 33° 33° C					6	- - -	48° 54° 55° 7			
9 0	50° 75° 76° 75° 1					9	61° 30° 32° 35° 33° 3					9	- - -	57° 58° 53° 4			
12 4	1° 72° 75° 72° 3					12	64° 14° 33° 35° 32° 3					12	- - -	54° 62° 49° 5			
15 8	1° 72° 75° 72° 3					15	63° 35° 34° 37° 33° 4					15	- - -	47° 58° 57° 11			
18 12	26° 72° 74° 73° 2					18	65° 58° 3° 34° 33° 1					18	- - -	52° 58° 47° 11			
21 17	9° 73° 73° 72° 1					21	62° 45° 33° 33° 34° 1					21	- - -	54° 57° 44° 13			
24 21	3° 72° 72° 71° 1					24	58° 24° 34° 35° 33° 2					24	- - -	49° 54° 49° 5			
27 24	4° 72° 72° 70° 2					27	56° 30° 33° 35° 33° 2					27	- - -	47° 57° 49° 10			
30 26	5° 97° 71° 2					30	51° 31° 30° 33° 39° 1					30	- - -	47° 57° 49° 52° 7			
Oct. 3	28° 46° 61° 61° 2					reb.	349° 15° 44° 44° 43° 1					June 1	- - -	56° 56° 50° 0			
6 29	42° 96° 58° 3					6	48° 53° 42° 45° 43° 3					3	- - -	53° 58° 51° 7			
9 33	52° 95° 57° 2					9	50° 17° 43° 43° 41° 2					6	- - -	52° 56° 47° 9			
12 34	49° 76° 58° 58° 1					10	51° 41° 38° 40° 37° 3					9	42° 50° 55° 52° 48° 7				
15 35	3° 58° 63° 57° 6					15	52° 13° 37° 38° 39° 2					12	45° 45° 51° 54° 47° 7				
18 34	33° 53° 57° 53° 4					18	52° 52° 37° 40° 37° 3					15	46° 45° 54° 49° 47° 7				
21 35	31° 57° 59° 55° 4					21	52° 15° 40° 41° 38° 3					18	45° 50° 49° 49° 47° 2				
24 36	39° 54° 57° 57° 3					24	52° 7° 40° 43° 41° 3					21	44° 17° 50° 51° 50° 1				
27 33	47° 57° 61° 60° 4					26	51° 18° 43° 44° 44° 1					24	43° 42° 47° 52° 49° 5				
30 33	55° 56°					27	50° 47° 45° 43° 45° 2					27	42° 23° 52° 53° 51° 2				
	Cape of Good Hope.					28	50° 24° 43° 43° 44° 1					30	43° 15° 52° 50° 2				

The observations contained in the above, and the former tables page 143, 145, 147, together with those related in various other parts of the same chapter evidently shew,

First, That the climate of North America is more subject to extremes of heat and cold, and to more sudden transitions from one extreme to another, than the climate of Great Britain.

Secondly, That the temperature of the air upon islands is likewise subject to greater vicissitudes than the air at sea: insomuch that if the earth was again universally covered with water, as in its primitive state, neither frost nor snow, nor a degree of cold equal to that of freezing, could have any existence in the natural world: for it evidently appears that the burning heats of the torrid zone and the intense cold of the frigid zones, do not altogether arise from their different situations on the globe, with respect to the line, but principally from those vast tracts of land the continents: for it seems to be an undoubted truth, that the high seas have at all times been found open and rolling like the Bay of Biscay; which seems to imply, that the regions of the North Pole are not occupied either by ice or land; and as a corroborating testimony, it has been observed that a north wind invariably produces a thaw

X

at

at the North Cape and Spitzbergen, and a south wind as invariably produces frost.

On the contrary, the quantity of ice in the southern hemisphere observed by the memorable navigator Capt. Cook, seems to imply the existence of land in the regions of the South Pole.

Hence it appears that extremes of heat and cold are consequences wholly arising from mountains, and those vast tracts of land the continents.

Therefore, since mountains and continents were not primary productions of nature, but of a very distant period of time from the creation of the world, namely, at the time of the deluge ; may we not thence reasonably infer, that the inclemencies of the seasons were totally unknown in the antediluvian state of nature ?

Consequently, during that particular period of time, from the creation to the deluge ; its several regions were universally adapted to the various species of the animal and vegetable kingdoms : it is therefore reasonable to suppose they were inhabited by a much greater variety of species than could possibly exist according to the present constitution of nature, since the Primitive islands were only small protuberances raised by the flux and reflux of the tides, as sand-banks are formed in the sea, and were of little extent or elevation, compared to the mountains and continents in the postdiluvian world.

These

These circumstances being duly considered, seem to unfold those wonderful phenomena, which have so much perplexed the inquisitive naturalist: namely, the remains of marine and terrestrial animals, which are found imbeded not only in various parts of this kingdom, but in other parts of the world remote from their native climates. Instances of such phenomena are innumerable, and have usually been ascribed to an universal flood, but I presume it evidently appears, Chap. VII. that the marine *exuviae* were actually generated, and have lived and died in the very beds wherein they are found: and likewise that those very beds were originally the bottom of the sea.

The various phenomena of nature thus coinciding with physical reasoning, even down from the creation of the world to the present time, leave little room to doubt but that the result thereof has some foundation in nature, and that all the matters contained therein are parts of one great whole. However that may be in reality, I have the pleasure to think that the facts are fairly stated, and that I have no other object in view than the investigation of truth.

Now since it appears that the antediluvian world was universally inhabited by all the various species of the animal creation, previous to the commencement of moun-

tains and continents, the following consequences would necessarily ensue.

First, Those animals and vegetables, whose constitutions were not formed to withstand the various inclemencies of the seasons, would consequently perish.

Secondly, Those which survived and enjoyed the change of temperature, became the native animals or plants of those climates which they found suitable to the nature of their existence.

Such I presume were the consequences arising from the great change in the constitution of nature, which only commenced at the time of the deluge.

Some instances similar to the above, with respect to the effects of change of climate, happened on the western coast of England in the year 1739: namely, the adjacent seas previous to that æra were plentifully stored with scollop-shell fish: but such was the severity of that intense frost, that they were almost destroyed. Whence it is evident that those animals could not exist in cold climates.

As the subject before us is of some importance, I presume the following question may arise: namely, How comes it to pass that the high seas are open, when those in lower latitudes are frozen up? To which I answer, That the severity of the latter is wholly owing to the

near

near approach of the two continents ; and that the former may be ascribed to an extensive fathomless sea.

To such like causes we may ascribe the destruction of various species of animals and vegetables, in different regions of the earth, subsequent to the grand convulsion.

The preceding circumstances seem to imply, that the *exuviae* of marine animals found remote from their native climates, are so many incontestible evidences of the alterations produced on the superficial parts of the earth at the time of the deluge ; and not as testimonies of the deluge itself : for, it cannot be supposed that a bed of oysters, &c. could have been removed two or three thousand miles from their native climates, in the space of two or three months, and with so much order, as to form select beds of oysters, cockles, &c. as living fish do in the ocean.

Other instances might be given to shew the improbability of such effects being produced ; but we presume, the above may suffice to explode the idea of their having been brought from distant regions by a flood or floods of water ; and also to convince us, that the alterations produced in the constitution of the climates, and the deluge itself, were undoubtedly effects of the same cause, and commenced at one and the same time, as represented Chap. XII.

As

As the subject immediately under consideration seems to be a very interesting branch of natural history, I hope it will merit a particular attention from my learned readers: conceiving it may throw some light upon the learning and philosophy of the ancients, with respect to the temperature and fertility of the first ages, as represented by Homer, Hesiod, Ovid, and others.

Before we conclude this chapter, it may not be improper to recite some instances of animal remains being found remote from their native climates, as a corroborating testimony of the preceding conclusions.

*A CATALOGUE of EXTRANEous FOSSILS, shewing where they were dug up; also their native Climates. Mostly selected from the curious Cabinet of the late Mr. NEILSON, in King-street, Red-Lion Square.*

Their Names and Places where found.	Native Climates.
-------------------------------------	------------------

CHAMBERED NAUTILUS. Sheppy Island, } Chinese Ocean  
Richmond in Surrey, Sherborne in } and other Parts  
Dorsetshire - - - - of that great  
Sea.

TEETH OF SHARKS. Sheppy Island, } East and  
Oxfordshire, Middlesex, Surrey, Nor- } West Indies.  
thamptonshire - - - -

SEA

**SEA TORTOISE**, several kinds; the  
*Hawksbill, Loggerhead, and Green* } *West Indies.*  
 Species. Sheppy Island - - - - -

**MANGROVE TREE OYSTERS.** Sheppy }  
 Island - - - - - } *West Indies.*

**COXCOMB TREE OYSTERS.** Oxfordshire, }  
 Gloucestershire, Dorsetshire, and Han- }  
 over - - - - - } *Coast of  
Guinea.*

**VERTEBRAE, and PALATES of the ORBES.** }  
 Sheppy Island, and many other parts }  
 of England - - - - - } *East and  
West Indies.*

**CROCODILE.** Germany, Derbyshire, }  
 Nottinghamshire, Oxfordshire, and }  
 Yorkshire - - - - - } *Africa.*

**ALLIGATOR'S TEETH.** Oxfordshire, }  
 Sheppy Island - - - - - } *East and  
West Indies.*

**THE BANDED BUCCINUM.** Oxfordshire, }  
 and the Alps - - - - - } *West Indies.*

**THE DIPPING SNAIL, and STAR FISH.** }  
 Sheppy Island - - - - - } *West Indies.*

**TAIL BUCCINUM.** Sheppy Island, Hor- }  
 del Cliff in Hampshire - - - - - } *East Indies.*

**BAMBOO,** Derbyshire - - - - - *East Indies.*

**ASTERIA,** Stanton in Nottinghamshire *Barbadoes.*

The remains of marine animals thus apparently removed from their native climates are innumerable: therefore let the above instances be admitted as sufficient testimony of the truth thereof.

The preceding catalogue of animal *exuviae* is principally selected from the marine creation, as they live in a more perfect state of freedom than the terrestrial animals; and therefore we may suppose, they would naturally inhabit the climates most agreeable to the nature of their existence.

Now since it appears, that the *exuviae* of marine animals are found remote from their native climates, and accompanied with a variety of circumstances, shewing that they were actually generated in the climates where they are found; it appears highly probable that those climates were originally suitable to the nature of their existence. It is therefore evident that the antediluvian world was more universally inhabited, than the postdiluvian state of nature.

Considering the great diversity of seasons before and after the flood, let us inquire into their different effects on the period of human life.

CHAP.

## C H A P. XIV.

*Of the Period of Human Life, before and after  
the Flood.*

**A**CCORDING to Chap. XII, mountains and continents were not primary productions of nature, but that of a very distant period of time from the creation of the world: namely, a time wherein the limestone *strata* had acquired their greatest degree of cohesion and firmness: and a time too wherein the testaceous matter of marine shells was become changed to a stony substance: which circumstances indicate a considerable period of time elapsed from the creation to the deluge.

And according to Chap. XIII, mountains and continents were productive of very considerable alterations in the temperature of the air and seasons of the year: for it evidently appears that they put a final period to that universal temperature which prevailed over the antediluvian world, and occasioned one perpetual spring and harvest; for the burning heat of the torrid zone, and the intense cold in the frigid zones commencing with mountains and continents, divided the year into four seasons, namely, summer and winter, spring and autumn.

Y

Such

Such were the great changes wrought on the constitution of nature, at the time of the deluge: therefore let us inquire what effects these great alterations on the atmosphere produced on the period of human life.

1. It is a truth commonly known, that temperate climates are more friendly to animal or vegetable life, than those subject to great and sudden changes from extreme of heat and cold to another.

2. Invalids are commonly sent from their native to a more temperate climate to recruit their constitutions, and seldom fail of being benefited thereby. May we not thence infer, that if a temperate air proves instrumental in restoring a weakly constitution, that it may likewise contribute to prolong the life of an healthy one?

3. To the same purpose the Rev. Dr. Burnet observes, in his Sacred Theory, vol. I. p. 275, 276. "I know no place, where people live longer than in the little island of Bermudas. According to the proportion of time they hold out there, after they arrive from other parts of the world, one may reasonably suppose that the natives would live two hundred years; and yet nothing appears in that island that should give long life above other places, but the extraordinary steadiness of the weather, and temperature of the air throughout the whole year, so that there is scarce any difference of seasons."

4. Lord

4. Lord Bacon likewise remarks, in his History on Life and Death, that “islanders are, for the most part, “longer lived than those that live on continents: for “they live not so long in Russia as in the Orcades; nor “so long in Africa, though in the same parallel of latitude, as in the Canaries and Terceras; and the Japanese are longer lived than the Chinese, though the Chinese are made for long life. And this is no wonder, seeing the air of the sea doth heat and cherish in cooler regions, and cool in hotter.

5. “The countries which have been observed to produce long lives are these, Arcadia, Aetolia, India on this side the Ganges, Brasil, Taprobane, Britain, Ireland, with the islands of the Orcades and Hibernides.”

6. Italy is generally considered as a more temperate climate than that of England, and productive of greater longevity; though we have many long-lived people in Britain. The above noble author recites the following instances of great longevity in the former, viz.

“The year of our Lord seventy-six, the reign of Vespasian, is memorable; for in that year there was a taxing. Now taxing is the most authentic method of knowing the age of men. In that part of Italy, lying betwixt the Apennine mountains and the river Po, there was found an hundred and twenty-four

“ persons that either equalled, or exceeded, an hundred  
 “ years of age : namely,

Fifty-four	-	-	100 years each.
Fifty-seven	-	-	110
Two	-	-	125
Four	-	-	130
Four	-	-	135 or 137
Three	-	-	140

“ Besides the above, Parma contained five ; whereof,

Three were	-	-	120 years each.
Two	-	-	130

One in Bruxells	-	125
One in Placentia	-	131
One in Faventia	-	132

“ A town near Placentia, ten ; whereof,

Six were	-	-	110 years each.
Four	-	-	120

One in Rimino - 150, whose name was  
 Marcus Aponius.”

His Lordship also enumerates many instances of much greater longevity than the above, but does not consider the records of them equally authentic with the former.

The following table contains many remarkable instances of longevity in Great Britain and Ireland, in the present age ; but we presume, they cannot boast of a number equal to the above, living at one and the same time.

## A T A B L E O F L O N G E V I T Y.

Names of the People.	Age.	Places of Abode.	Living or dead
Thomas Parre - - -	152	Shropshire	Nov. 16, 1635
Henry Jenkins - - -	169	Yorkshire	Dec. 8, 1670
Robert Montgomery - - -	126	ditto -	Living in the year 1670
Anonymous - - -	140	ditto -	{ Both living 1664
His Son - - -	100	ditto -	
The Countess of Desmond	140	Ireland -	
Mr. Ecleston - - -	143	ditto -	1691
J. Sagar - - -	112	Lancashire	1668
— Lawrence - - -	140	Scotland -	Living
Simon Sack - - -	141	Trionia -	May 30, 1764
Col. Thomas Winfloe - - -	146	Ireland -	August 22, 1766
Francis Consist - - -	150	Yorkshire	January 1768
Christian Jacob Drakenberg	146	Norway -	June 24, 1770
Margaret Forster - - -	136	Cumberland	{ Living 1771
Her Daughter - - -	104	ditto -	
Francis Bons - - -	121	France -	Feb. 6, 1769.
John Brookeey - - -	134	Devonshire	Living 1777
James Bowels - - -	152	Kilinworth	August 15, 1656
William Mead, M. D. - - -	148	Ware -	October 28, 1652
John Tice - - -	125	Worcestershire	March 1774
John Mount - - -	136	Scotland -	February 27, 1776
A goldsmith - - -	140	France -	June 1776
Mary Yates - - -	128	Shropshire	— 1776
William Bren - - -	121	Brunston -	
Jeremiah Gilbert - - -	132	Apthorp -	
John Bayles - - -	126	Northampton	April 5, 1706
Martha Waterhouse - - -	140	Biesley Yorksh.	
Hester Jagar her Sister - - -	107		
A woman - - -	154	Cornwall -	
John Campbell - - -	112	Dungannon Ir.	Living 1783
William Ellis - - -	130	Liverpool	August 16, 1780
Dumiter Radaly - - -	140	Harmenstead	January 16, 1782
Val. Catby - - -	116	Preston, Hull	October 1782
William Evans - - -	145	Carnarvan	Living 1782
James Southwell - - -	116	Limerick	
Lewis Jones - - -	113	North Wales	1784
Hugh Rowland Hughes	114	ditto -	1784

The above table of longevity was mostly selected from the public papers, by a gentleman whose veracity may be relied on, though the authorities are omitted.

To the above we may add, that the natives of North America are shorter lived than those of Great Britain and Ireland; and likewise that a British constitution will last longer in America than a native one. This information I received from the best authority.

The foregoing observations evidently shew that temperate climates prolong the period of human life in the postdiluvian state of nature; and therefore it seems reasonable to infer, that the same cause might have produced the same effect in the antediluvian world: since it appears according to the preceding chapter, that a more universal temperature prevailed over the different regions of the earth before the flood, than subsequent to it.

Whence we may infer, that the longevity of the antediluvians must have been greatly superior to that of the postdiluvian race of men. And this conjecture is rendered much more probable when we consider that our first parents were created with constitutions perfectly free from all those taints and impurities, acquired by intemperance in after ages; and that they were also provided with food the most suitable to the nature of their existence.

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Therefore, if so many of the postdiluvians have survived the age of an hundred and twenty, or an hundred and thirty, under all the disadvantages of constitution, climate, &c. the presumption is great, that the antediluvians might have lived to the age of many hundred years according to the scripture account.

Other circumstances apparently concurred to prolong the lives of the antediluvians: namely, according to Chap. VI. the Primitive islands were of no considerable extent or elevation compared to the mountains and continents in the postdiluvian world: and therefore according to Chap. XIII. the temperature of the air and seasons in the antediluvian world, and the succulent state of the earth's surface, seem to have rendered the vegetable productions extremely luxuriant at all times of the year, insomuch as to supply the calls of human nature without the least art or labour.

Hence no anxious thoughts or jealousies invaded their repose; property and dominion being then unknown, men passed away their time in sweet repose on the ever verdant turf.

Therefore, since harmony thus prevailed universally both in the moral and the natural world, we may therefore conclude that so many concomitant causes co-operating towards one and the same end, might probably stretch out the period of human life much beyond the reach

reach of our conceptions; nay even to that of near one thousand years, as recorded in the scripture accounts.

Such appear to have been the consequences arising from the preceding causes: but alas! the most permanent state of human felicity is liable to invasion from natural causes, and particularly in the instance immediately under consideration: for according to Chap. XII. the Primitive islands were not only deluged by means of that horrid convulsion, but the whole fabric of the earth was burst into millions of fragments, and thrown into the greatest heaps of confusion; and those inequalities destroyed that universal temperature and fertility of the earth, which prevailed in the antediluvian world.

The earth now became subject to the burning heats of summer, and the severities of winter; mankind were also reduced to the necessity of sowing, reaping, and of laying up a winters store; for the great changes wrought in the constitution of the atmosphere, put a final period to the spontaneous productions of the earth: therefore, he who sowed would expect to reap the fruits of his own labours; and he who contrived the means of protecting himself from the inclemencies of the seasons, would naturally expect to enjoy an exclusive right to the works of his own hands. Hence commenced

pro-

property, which previous to that convulsion, had no existence amongst mankind.

Necessity therefore may be considered as the parent of property, and the consequences arising from property are, creating a thousand unnatural wants, which its possessors studiously endeavour to gratify; and their example creates similar ideas in those who have it not, but who nevertheless attempt to satisfy their imaginary wants by unnatural means.

Hence the necessity of law, dominion, and subordination, which before that epoch were unnecessary and unknown: for the calls of human nature being so bountifully provided, rendered all government, law, or division of property useless: for in such a state there could be no temptation to dishonesty, fraud, injustice, or violence; nor indeed any desires which might not be gratified with innocence.

Hence that proneness to vice, which civilized nations have thought to be natural, cannot possibly exist in a state of nature like this, where every one equally partakes the blessings of life, which the author of nature has thus amply provided for him.

All these circumstances being duly considered, seem to imply that the period of human life began to contract gradually from that particular æra, to its present standard: for since a constitution removed from a temperate,

to an intemperate climate, will last longer than a native constitution; by parity of reason we may infer, that the antediluvians would live much longer in the postdiluvian world than those born after the flood.

Having considered the consequences arising from the great revolutions in the natural world, on the period of human life, let us take a view of the ancient records, and observe their agreement with the result of the preceding inquiries.

LONGEVITY before the FLOOD.		LONGEVITY after the FLOOD.	
	Years.		Years.
Adam	930	Noah after the Flood	350
Seth	912	Shem after the Flood	502
Enos	905	Arphaxad	438
Cainan	910	Salah	403
Mahalalul	895	Eber	464
Jared	962	Peleg	239
Metheuselah	969	Reu	239
Samech	777	Serug	230
Noah before the Flood	600	Nahur	148
Shem before the Flood	98	Terah	205
		Abraham	175
		Isaac	180
		Jacob	147
		Ruben	124
		Simeon	120
		Levi	137
		Judah	119
		Dan	124
		Naphthali	130
		Gad	125
		Asher	126
		Isaacchar	122
		Zebulon	114
		Joseph	110
		Sarah	127
		Kohath	133

According to the scripture account, Adam lived to the age of nine hundred and thirty, and Noah to the age of nine hundred and fifty.

Hence it appears, that the period of human life was not contracted during that period of time: we may thence

thence infer, that the temperature of the air and seasons suffered no alteration before the flood. These circumstances perfectly coincide with the result of former reasonings, relative to temperate climates prolonging the period of human life.

And it is, also evident from the same authority, that the period of human life became gradually contracted from the flood to the days of Terah, to that of 205 years; and as the greatest part of Jacob's numerous family lived to the age of 120 years and upwards, we may consider that period to have been the ordinary age of mankind in that particular æra.

Such was the longevity of human life at sundry periods of time. First before the flood. Secondly 898 years after the flood. Thirdly in the year 76: and fourthly, from the year 1635 to the year 1783 of the Christian æra. All of which circumstances seem to coincide with the operations of nature before mentioned. Hence it appears, that the causes assigned for the various periods of human life have some foundation in nature; and therefore seem to corroborate the conclusions we have drawn, with respect to the primitive state of the earth, the deluge, and the production of mountains, continents, and their effects on the temperature of the air, the seasons of the year, and the longevity of mankind: and therefore it is presumed, that future obser-

vations may give these reasonings a lasting foundation. But however that may be, I have not at present discovered that any part of the work hitherto advanced, is in any degree repugnant to the laws or operations of nature, or to the scripture account of the creation ; and their agreement I consider as a further testimony of the truth of each ; for when those relations are compared together, they seem to strengthen the preceding conjectures beyond a possibility of doubt.

And if I am not much mistaken, these deductions throw some light upon the supposed poetical fables of Homer, Hesiod, Ovid, &c. and shew that their works were not altogether fiction, but were derived from sundry phenomena in the natural world, or from histories thereof, of the most remote antiquity. These inquiries only fall within the province of the learned, and therefore I shall return to the remaining part of the subject ; which is to inquire into the first appearance of the rainbow.

CHAP.

## C H A P. XV.

*Concerning the Appearance of the Rainbow after  
the Flood.*

HAVING inquired into the state of the atmosphere in the antediluvian world, and its effects on the period of human life, let us extend our researches a little further, and endeavour to ascertain the æra when the rainbow first appeared.

That phenomenon is well known to arise from the rays of light refracted from spherical drops of rain descending towards the earth: therefore the appearance of the rainbow dependeth altogether on there being rain or no rain before the flood.

According to the preceding chapters, the antediluvian atmosphere was more constant and uniform in its temperature, and more homogeneous than that in the postdiluvian world: for in the former there were no fissures or volcanos to impregnate the air with noxious vapours; nor continents to produce extremes of heat and cold: but on the contrary, harmony seems to have reigned universally over the new-formed globe.

Hence

Hence it appears, that the primitive state of the earth was also more free from storms and tempests than the present state and condition of it, and consequently more free from rain.

It is a general observation with mariners, that those parts of the ocean the most distant from land are the least subject to storms and tempests: nay, further, that storms are a certain indication of its vicinity.

Don Antonia de Ulloa observes, in his *Voyage to America*, vol. i. p. 13, that "in the ocean, the winds are so mild, that the motion of the ship is hardly perceived, which renders the passage extremely agreeable. "The atmosphere of the ocean," says he, "answers to the calmness of the winds and sea; so that it is very seldom an observation cannot be taken either from the sun's being obscured, or the haziness of the horizon."

Varanius remarks, that "the winds are most constant in the Pacific Ocean, viz. that part of it which lies between the tropicks; so that the ships which come from Aquapulco, a port in New Spain, in America, to the Philipine islands, that is from east to west, often sail three months, without ever changing or shifting their sails; having a constant east or north east wind. Nor did ever any ship yet perish in that vast voyage of one thousand six hundred miles. And

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“ therefore the sailors think they may sleep there securely: nor is there any heed of taking care of the ship when that general wind carries them strait to their desired port, the Philipine islands. And thus it is also in failing from the Cape of Good Hope, to Brazil in America, in the middle of which voyage lies the isle of St. Helena.” Varanius Geog. vol. i. p. 493.

“ Dr. Halley, a person well skilled in meteorology, as well as in all parts of physicks, has, with extraordinary accuracy, prosecuted the history of the constant periodical winds, which he deduces not only from the observations of seamen, but from his own experience. But he only takes notice of such winds as blow in the ocean; there being so much inconstancy and variability in land winds, that from them a person can make out nothing clear or certain.” See note to Varanius’s Geog. vol. i. p. 496.

Now since it appears that the atmosphere of the ocean is uniform in its temperature, and constantly unruffled by storms and tempests; though the atmosphere of continents is continually subject to violent emotions, and to great and sudden changes from one extreme of heat or cold to another; may we not thence conclude, that those vast tracts of land are the principal cause of the former, as well as of the latter? Therefore, as rain generally accompanies storms, it becomes highly probable that

that they both arise from one and the same cause, and may be considered as inseparable.

Now as storms and tempests only commenced with the production of mountains and continents, it seems highly probable, that rain also commenced at the same time.

Therefore, as an uniform temperature universally prevailed in the antediluvian atmosphere, it is highly probable that it was not subject to storms and tempests, and consequently not to rain; and if there was no rain most certainly no rainbow.

Hence the first appearance of the rainbow seems to have commenced at the time of the deluge, with the production of mountains, continents, &c. Its appearance therefore, at that particular æra, is consistent with the general order and progression of things.

It may, however, be objected, that a want of rain for so many hundred years, as from the creation to the deluge, would be greatly injurious, if not totally destroy the vegetable kingdom: but we presume such objections will vanish when the state and condition of the Primitive islands is truly considered.

1. The scorching heats of summer, and the severities of winter, were not commenced.

2. The superficial contents of the islands being so much inferior to that of the continents, the surface of

the sea, and the quantity of aqueous particles exhaled, were proportionably greater.

3. The atmosphere being thus more plentifully saturated with humidity, the latter descended more copiously in dews, during the absence of the sun, and abundantly replenished the earth; rendered its surface soft and succulent, and its vegetable productions luxuriant.

Such being apparently the state and condition of the antediluvian world, we cannot suppose that rain was in the least necessary, either for the animal or the vegetable creation: and therefore, during that long period, it is highly improbable there should have been either rain, or a rainbow: for as the causes productive of rain only commenced at the time of the deluge, may we not conclude, that the appearance of the rainbow could not precede that æra?

Having now completed my inquiries into the original state and formation of the earth, and the changes it has undergone, I purpose giving some account of the *strata* in Derbyshire, and their various productions of animal, vegetable and mineral substances, as an illustration of the preceding chapters.

## C H A P. XVI.

*Of the Strata in Derbyshire and other parts of England.*

THE following observations on the *strata* of the earth, are not only intended as an illustration of the preceding inquiries, into the original state and formation of the earth, and the great changes it has undergone; but likewise to represent the advantages arising from a System of Subterraneous Geography—A science not merely speculative, but subservient to the purposes of human life; by leading mankind to the discovery of many things of great utility which lied concealed in the lower regions of the earth.

The arrangement of the *strata* in general is such, that they invariably follow each other, as it were, in alphabetical order, or as a series of numbers; whatever may be their different denominations.

I do not mean to insinuate that the *strata* are alike in all the different regions of the earth, either with respect to thickness or quality; for experience shews the contrary. But that the order of the *strata* in each particular part, how much soever they may differ, as to quality,

quality, yet they follow each other in a regular succession, both as to thickness and quality: insomuch that by knowing the incumbent *stratum*, together with the arrangement thereof in any particular part of the earth, we come to a perfect knowledge of all the inferior beds, so far as they have been previously discovered in the adjacent country; of which the following pages contain many instances.

With respect to the *strata* accompanying coal, I have observed some instances which apparently contradict that general rule, though they do not in reality.

The mountainous part of Derbyshire affords innumerable instances of the uniform arrangement of the *strata*, and also of their various productions of animal, vegetable, or mineral substances, or rather of the figures or impressions of the two former. And these discoveries have arose from the numerous perforations through the *strata* in search of minerals, and also from the violent convulsions which they have suffered, anterior to history or tradition; whereby the *strata*, which lay in the lower regions of the earth, were thrown up to the surface.

I say by means of such operations of nature and art, the thickness, quality, and position of the *strata*, have been truly ascertained, as represented in the sections given at the end of the work.

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And in order to render the different denomination of the *strata* obvious by inspection, I have attempted to assign a particular character to each of them, by hatched lines, as colours are represented in coats of arms; considering that a faithful representation of the *strata*, to be a matter of much importance, not only to the maintainers of mines, but also to practical miners; presuming they may be enabled thereby, to prosecute their mineral researches with more propriety and advantage to themselves and to the public.

It is not only in mineral operations that faithful records of the *strata* are requisite, but also in attempting to discover either salt or fresh-water springs, coals, &c. therefore in order to render the subject of subterraneous geography of general use; whether pits are dug for water or minerals, such records will be found beneficial: for the more general the observations, the more conclusive the inferences thence deduced. I am very doubtful whether the mode I have chosen is the best possible for that purpose, and therefore, should gladly receive any hints tending towards the improvement of so valuable a branch of Science.

It was my intention to have deposited specimens of each *stratum*, with its productions, in the British Museum, arranged in the same order upon each other, as they are in the earth; being persuaded that such a plan would

would convey a more perfect idea of Subterraneous Geography, and of the various bodies contained in the earth, than words or lines can possibly express: and though I have not hitherto been able to complete this design, yet I am still in hopes of doing it some future day.

It is not my intention to enter into a minute description of the various stones, minerals, petrefactions, &c. but rather to represent the general state and condition of the *strata*, and the changes they have undergone from various causes. Neither do I assume to myself the sole honour of the following observations, having principally obtained them from several experienced miners; and particularly from Mr. George Tissington, late of Winster.

I have, indeed, very assiduously endeavoured to ascertain the truth of their reports by subterraneous visits, &c. and have also made some discoveries unnoticed by any other person before me: therefore, I am not conscious of any misrepresentations, arising either from neglect or a theoretical influence; neither am I insensible that much more remains to be done, and that in works of this nature, errors are unavoidable.

Plate I. fig. 6. represents a section of the *strata* between Grange Mill and Darley Moor. The upper outline shews the surface of the earth; the numbers 1, 2, 3, 4, &c. the respective *strata*. Under the river Der-

went is represented a fissure filled up with rubble; knowing that to be the state of all vallies wherein shafts have been sunk.

N<sup>o</sup> 1. MILLSTONE-GRET, 120 yards. A coarse sandstone, composed of granulated quartz and quartz pebbles. The former retain the sharpness of fragments newly broken, the latter are rounded by attrition as stones upon a sea beech. This *stratum* is not productive of minerals, nor figured stones representing any part of the animal or vegetable kingdoms.

The quartz pebbles contained in this *stratum*, indicate the pre-existent state of a quartzose *stratum*; for it is equally well known that quartz is a substance only, generated in the fissures of a quartoze *stratum*, as spar is found in those of limestone; and is not to be considered as parts of a *stratum*. Quartz pebbles therefore evidently shew the destruction of a quartzose *stratum*, the fragments whereof were rounded by attrition.

The quartz pebbles abovementioned are white; the colour of the quartzose stones from whence they are produced is various, as black, brown, &c. They are in common use for paving streets, and are frequently variegated with seams of white quartz running through them. They are the common gravel stone of Nottinghamshire, Staffordshire, Derbyshire, Cheshire, &c.

Quartz,

Quartz, or quartzose stone is analogous to flint; it strikes fire with steel, and resists acids: it is less hard than flint, and breaks with a rough surface.

We are told that the minerals in Norway and Sweden are contained in the fissures of a quartzose stone.

N° 2. SHALE or SHIVER, 120 yards. A black laminated clay, much indurated; it contains neither animal nor vegetable impressions, and is not considered as productive of minerals, as lead ore, spar, &c. though an instance or two has appeared to the contrary, in a mine called Shaw-Engine, near Eyam, attended with a curious circumstance, namely, a vein of lead ore in N° 3, ascended into N° 2, fifteen or twenty fathoms; and the higher it ascended, the less and less it was mineralized, till it terminated in a white mucus-like substance. I had this information from people of veracity. Quære, Was the ore generated from the mucus-like substance? or was that substance the product of ore decomposed by the acid contained in that *stratum*?

The above *stratum* contains ironstone in nodules, and sometimes stratified. The springs issuing from it are of the chalybeate kind: for instance, one near the bridge at Buxton, one at Quarndon, and another beyond Matlock Bridge, towards Chatsworth.

N° 3. LIMESTONE, 50 yards. Productive of lead ore, the ore of zinc, calamine, pyrites, spar, fluor, cauk,

cauk, and chert. The *stratum* also contains figured stones, representing various kinds of marine animals; as a great variety of *anominae bivalves*, not known to exist in the British seas; also *coralloids*, *entrochis* or screw-stones. I do not recollect ever seeing any univalves.

The impression of a crocodile was found in the above bed of stone, at Ashford, by Mr. Henry Watson of Bakewell.

The above *stratum* is composed of various *laminæ*, more or less separated by shale or shiver, a substance similar to N° 2; especially the upper, which are a good black, take a fine polish, and are thence called black marble. The lower *laminæ* are rather brown, as may be observed in the rocks composing Matlock High-Tor. The ore of zinc, commonly called black-jack or mock-ore, is but recently discovered as the ore of zinc. The appellation of mock-ore might probably arise from its similitude to lead ore. When compounded with copper it makes bras, as calamine. Calamine, though similar in its mineral qualities, is apparently a simple brown earth; it is commonly used in medicine by the name of *lapis calaminaris*.

N° 4. TOADSTONE, 16 yards. A blackish substance, very hard; contains bladder-holes, like the *scoria* of metals, or Iceland *lava*, and has the same chymical property of resisting acids. Some of its bladder-holes

are

are filled with spar, others only in part; and others again are quite empty. This *stratum* is not laminated, but consists of one entire solid mass, and breaks alike in all directions. It does not produce any minerals, or figured stones representing any part of the animal or vegetable creation, nor any adventitious bodies enveloped in it; but is as much an uniform mass as any vitrified substance whatever: neither does it universally prevail, as the lime-stone *strata*; nor is it, like them, equally thick; but in some instances varies in thickness from six feet to six hundred, as will be shewn hereafter. It is likewise attended with other circumstances which leave no room to doubt of its being as much a *lava* as that which flows from Hecla, Vesuvius, or Ætna.

The various circumstances relative to this apparent lava will be considered in their due place, with some attempt to investigate the cause of its introduction between the lime-stone *strata*; and to shew why it did not overflow the surface of the earth, according to the usual effects of volcanic eruptions.

It is to be remembered that the above *stratum* is known by different names in different parts of Derbyshire, viz. At Matlock and Winster, *toad-stone* and *black-stone*; at Moneyash and Tideswell, *channel*; at Castleton, *cat-dirt*; at Ashover, *black-clay*.

N<sup>o</sup> 5. LIMESTONE, 50 yards. This *stratum* is laminated like the former, N<sup>o</sup> 3, and contains all the same kinds of minerals and figured stones. It is likewise productive of the Derbyshire marble, so much esteemed for its beauty and excellence in slabs and chimney-pieces. It abounds more plentifully with *entrochi*, or screw-stone, than any other marine productions. The quarry from whence this marble is commonly raised, is situate on Moneyash Moor, near the road, between that town and Bakewell; its colour is grey.

N<sup>o</sup> 6. TOADSTONE, 46 yards. This *stratum* is similar to N<sup>o</sup> 4, in colour and chemical properties; but yet more solid, and freer from bladder holes, as may be observed in Mosey-Meer mine, near Winster.

N<sup>o</sup> 7. LIMESTONE, 60 yards. Laminated like the former N<sup>o</sup> 3 and 5, and like them contains minerals, and figured stones; but fewer of the latter. Its colour is much whiter than N<sup>o</sup> 5.

N<sup>o</sup> 8. TOADSTONE, 22 yards. This *stratum* is similar to N<sup>o</sup> 6, but yet more solid, as may be observed in Hubberdale mine, near Moneyash.

N<sup>o</sup> 9. LIMESTONE, not yet cut through. Productive of minerals and figured stones, like the former, N<sup>o</sup> 3, 5, and 7, but very few of the latter.

N. B. NO VEGETABLE FORMS HAVE YET BEEN DISCOVERED IN ANY OF THE LIMESTONE STRATA.

Such are the Derbyshire *strata*, and their productions, qualities, and characters by which they are represented plate I. fig. 1. and it is necessary to observe further, that the same characters are applied to express the same qualities, in all the other sections.

To the above we may add six other *strata*, which are too minute to be expressed on the same scale: these are usually called *clays*, or *way-boards*; in general they are not more than four, five, or six feet thick, and in some instances not more than one foot. Their colour is a lightish blue, with a small tint of green; they all contain pyrites and spar in small nodules; and it has been observed by Mr. George Tissington, that all the springs flowing from them are warm, like those at Buxton and Matlock-Bath. These clays are calcarious, and may therefore be classed with marls. They are arranged in the following order:

The first *stratum* of clay separates N° 3 and 4; the second, N° 4 and 5; the third, N° 5 and 6; the fourth, N° 6 and 7; the fifth, N° 7 and 8; the sixth, N° 8 and 9. By these clays the thickness of the other *strata* are ascertained, which otherwise would be difficult, as the limestone beds consist of various *laminæ*.

Having described the *strata*, and their various productions contained in plate I. let us take a general view of them. It is to be observed that this section is only

intended to represent the arrangement of the *strata*, and not all the particular circumstances accompanying them, with respect to their several fractures, dislocations, &c.

To proceed: The lower *strata* appear at the surface on Bonsal Moor, and the upper in Darleydale: for instance, N° 2, on the banks of the river Derwent; N° 3, in Trogues-pasture; N° 4, 5, 6, 7, and 8, on Bonsal Moor, although the elevation of that mountain cannot be less than eight hundred or a thousand feet above the level of the river Derwent. When the lower *strata* thus appear at the surface, they are said, by miners, to basset.

What has been observed of the lower *strata* basseting on Bonsal Moor, is likewise true in many other parts of Derbyshire. For instance: *stratum* N° 2, appears in the vallies of Bakewell, Ashford, and Castleton; and likewise on Mam-Tor, although that mountain is nearly a thousand feet above the level of Castleton valley. N° 4, forms the summit of a mountain adjacent to the castle, and is known there by the name of *cat-dirt*. N° 5, forms the surface of Moneyash Moor, particularly at the marble quarry; and likewise at Hubberdale mine, although that mountain cannot be less than seven or eight hundred feet above the level of Bakewell or Ashford vallies.

Let

Let us now take a view of plate II. fig. 2; which represents a section of the *strata* at Matlock High-Tor. N° 1, 2, 3, 4, 5, &c. on each side the river, shew the corresponding *strata*; whence it appears that they have been burst, dislocated, and thrown into confusion, by some violent convulsion of Nature.

The *strata* which compose the top of Masson mountain, are elevated about one hundred yards above the summit of Matlock High-Tor; and the same beds are depressed about one hundred yards below the foot of it, at the river, as shewn in the plate. A, represents a great fissure or chasm, filled up with the fragments of the upper and adjacent *strata*.

Such is the general state of the mountainous part of Derbyshire, which perfectly coincides with the result of Chap. XII. p. 119: and therefore, serves to shew the effects produced by subterraneous convulsions; and likewise that mountains are not primary productions of nature, but of a very distant period of time from the creation of the world.

Whence it appears, that all such vallies were originally great gulfs or fissures thus filled up with rubble or fragments of the upper *strata*. Therefore, as the *strata*, N° 1 and 2, have totally disappeared on the west side of the river, together with a part of N° 3, the presumption is great that they have been thus swallowed up into that

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enormous cleft ; and if in this instance, the same thing may have happened in many others ; if not universally, in all mountainous countries, wherein the upper *strata* have disappeared. For in Derbyshire, wherever miners have had occasion to dig in vallies, they invariably find them thus filled up with fragments of the superior beds.

It may appear strange to our imagination, that such immense masses of earth should have been thus totally absorbed into the bowels of the earth ; but when we consider the probability of these gulfs being many miles or many hundreds of miles deep, according to Chap. XII. it will no longer remain a matter of wonder what is become of the superincumbent *strata*, so often missing among the mountains ; but rather that those horrid chasms should have been so nearly filled up.

R, represents a mine called High-Tor-Rake. B, B; B, the corresponding fissures, separated by beds of toadstone.

When I speak of incumbent beds, I do not confine myself to those of millstone grit, shale, limestone, &c. but I also include those of argillaceous stone, clay and coal : for according to plate III. fig. 3, and 4 ; and likewise plate IV. fig. 1. wherever *stratum* N° 1, dips, or disappears, as there represented, those of argillaceous stone, clay, and coal, become the incumbent beds : there-

therefore, since this observation holds universally true in Derbyshire, Shropshire, and Staffordshire, it seems highly probable, that the *strata* of clay, coal, &c. there represented, have been originally incumbent on grit, and were swallowed up by that dreadful convulsion which burst the *strata* and threw them into all this disorder. However that might have been, such is their present state; therefore I leave the reader to draw his own conclusions.

Let us now return to plate I. fig. 6. A, A, A, and G, G, G, G, represent the corresponding fissures in the limestone *strata*, intersected by beds of solid toadstone. All the fissures thus correspond in the limestone *strata* in Derbyshire; not a single instance knowingly, has happened to the contrary; but it does not follow that they are all thus intersected; for we have many instances where the *strata* N° 4, and 6, do not exist, as will be shewn hereafter: neither are they equally thick, as represented in the section, although the upper and lower surfaces of the other *strata*, are nearly parallel; but more of this in its due place.

It is a general observation, and invariably true, that minerals are only contained in the fissures of limestone *strata*, and between their *laminæ*, and not in the solid substance of the stone. When they are discovered in the

the fissures, the mines are called rake-works: when between the *laminæ*, pipe-works.

The following mines are instances of the several limestone *strata* producing lead-ore.

Yate-stoop in	<i>stratum</i>	- - - -	N° 3.
Portaway and Placket in		- - -	N° 5.
Mosey-meer in		- - - -	N° 7.
Gorsey-dale in		- - - -	N° 9.

All the *strata*, except toadstone, may be considered as equally thick, when covered by an incumbent bed; but when exposed to the operations of the air, they are greatly diminished in thickness, or decomposed as it were, and changed to a vegetable mould, whether grit, limestone, or toadstone: for it is observable, that the effects of the weather extend many feet below the surface of the earth. Immediately under the soil, the fragments of the stone are small, and gradually increase in bulk to the depth of fifteen or twenty feet, where the *stratum* generally becomes solid, and fit for the mason.

We have now to observe of the *strata* in general, that wherever N° 1 appears on the surface, N° 2 lies certainly underneath it; where N° 2 forms the surface, N° 3 is the succeeding *stratum*; and this holds true with all the other *strata*, where any observations have been made, the toadstone excepted: and therefore

fore since grit and shale are now only to be found in broken detached parts, dispersed over the mountainous parts of Derbyshire; it appears highly probable, that they have originally prevailed universally over that part of the country, according to our observations on the argillaceous stone, clay, coal, &c.

Let us now take some notice of the toadstone, since it appears to have been formed by a different cause.

We have already observed, that toadstone intersects the mineral veins, and totally cuts off all communication between the upper and the lower fissures.

Hence it is that when a mineral vein in N° 3, is cut down to N° 4, all mineral appearances totally vanish. But experience, the great master in physical researches, has taught the miner to dig through the toadstone to the limestone N° 5, where he never fails finding the corresponding vein, as above represented, or nearly so.

The above facts may be considered as universally true; and therefore merit a particular attention, as they will be called forth hereafter to prove the origin of toadstone.

Another circumstance accompanying toadstone, is, the closeness of its texture; a property of great utility in the practice of mining: for instance, suppose the springs in a mine at I. plate I. fig. 6. near Wensley,

C c

were

were either too powerful, to be raised by an engine, or the expence of raising them too great, the work then stands, and a shaft is sunk at an upper level at O, down to N° 5 at a, and a gate or gallery driven under N° 4 to the corresponding fissure at G. This is a common practice among the miners in Derbyshire, and never fails producing a dry work in *stratum* N° 5; for the close texture of the toadstone will not filtrate water sufficient to incommod the work-men, although it may be ten or fifteen fathom deep in N° 3, as represented by the horizontal line L, L. This circumstance likewise shews that the toadstone is free from fissures.

Another circumstance accompanying toadstone, is, that it frequently fills up fissures in the limestone *strata* immediately under it, and this, more or less, as they are more or less wide, see S, H, plate I. fig. 6. When fissures are thus filled up, the miners call it *troughing*. Two such instances have been discovered on Bonsal Moor; one of them in the mine called Slack; the other in that called Salters-way. In the former there are two fissures which intersect each other, called a cross-rake: one of them contains toadstone, the other minerals. See plate I. fig. 2. A, B, the mineral vein, totally separated by the toadstone F, F.

It is necessary further to observe, that a shaft was sunk at this mine forty or fifty fathoms deep in toadstone,

stone, and no bottom yet found. Another shaft was sunk about sixty yards from the former, towards the east, and the same toadstone was found about twenty fathoms thick. Another shaft was also sunk about the same distance towards the west, and the toadstone was found near twenty fathoms thick. These circumstances seem to shew, that the first shaft was sunk in a fissure.

Similar instances are not uncommon, therefore the above may be considered as characteristic of the mineral part of Derbyshire.

In the mine called Salters-way, a fissure has been discovered in part filled up with toadstone, and in part with the fragments of limestone, minerals, &c. See the section, plate I, fig. 3. F, F, F, represents the toadstone.

On Tideswell-Moor, the toadstone, or channel, as there called, has been dug one hundred fathoms deep, and no bottom found; though in seven other mines adjacent, the same stratum has been dug through, and its thickness ascertained at each place, as under.

<i>Names of the Mines.</i>	<i>Fathoms.</i>
A. Black Hillock	100 not cut through.
B. Heath Bush	16 cut through.
C. St. Andrew's	2 ditto.
D. St. James's	22 ditto.
C c 2	E. Con-

<i>Names of the Mines.</i>	<i>Fathoms.</i>
E. Constant	7 cut through.
F. Calvestone	7 ditto.
G. Dunkirk	19 ditto.
H. Chap-maiden	17 ditto.

Plate IV. fig. 2. shews the situation of each shaft where the observations were made, by Mr. William Haigh of Tideswell.

The above may serve to shew that toadstone is so extremely variable in its thickness, as not to admit of being truly represented by a section. Let us now enumerate a few instances where this stone has not yet been found, *viz.*

In the mines at Eyam and Foolow, although those mines are sunk near fifty fathoms in the limestone; and the *stratum* N° 5, forms the surface of the earth at Foolow.

The *strata* N° 4 and 6, are not universal; they have no existence in Hubberdale mine, near Moneyash; Hangworm mine, on Bonsal Moor; nor at High-Rake mine, near Tideswell.

Hence it evidently appears, that toadstone is attended with many peculiar circumstances very different from the other *strata*. 1. It is perfectly similar to Iceland lava in its appearace and chymical quality. 2. It is extremely

extremely variable in its thickness. 3. It is not universal. 4. It has no corresponding fissures to those in limestone. 5. It frequently fills up the fissures in the *stratum* underneath it, more or less, as they are more or less wide.

All these circumstances plainly evince, that toad-stone was formed by a very different law from the others, and greatly posterior to them; for the beds of limestone must have been formed before they were broken, and broken before their fissures were thus filled up: therefore we may, with much reason, conclude, that *toadstone*, *channel*, *cat-dirt*, and *black-clay*, is actual lava, and flowed from a volcano whose funnel, or shaft, did not approach the open air, but disgorged its fiery contents between the *strata* in all directions.

Another remarkable phenomenon accompanying the Derbyshire lava is that the *stratum* of clay lying under N° 6, is apparently burnt, as much as an earthen pot or brick; insomuch that when compared to the burnt clay on Heynor Common, they are not to be distinguished asunder. The Heynor clay was burnt by a *stratum* of coal being on fire underneath it, and is the best material in that neighbourhood for the repair of public roads. This argillaceous stone though much indurated, soon returns to its primitive clay by the pressure of coal carriages.

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The calcined clay mentioned above under No 6, is not peculiar to any one mine, but is commonly observed in all mines. The part in contact with the toad-stone is burnt about one foot thick.

Having enumerated the various circumstances relative to toadstone there can be but little doubt of its being actually a volcanic production. However probable that may appear, the intelligent reader may possibly ask by what process lava was introduced between such immense beds of stone?

The question is more easily stated than answered, yet seems to require a solution to establish its identity. We will therefore attempt the investigation, difficult as it may appear: for should we fail in the attempt, future discoveries may possibly afford a more satisfactory solution.

Previous to the inquiry, it is necessary to observe, that the introduction of lava between the limestone *strata* was anterior to the fracture represented plate II. fig. 2. This is evident from the corresponding *strata* on each side the river, and also from the fragments of the toadstone contained in the fissure. These circumstances likewise shew that the position of the *strata* was altered by the convulsion which occasioned the fracture, whence we may infer they had originally an uniform arrangement, concentric to the centre of the earth. And if

if in this instance, may we not conclude, by analogy, that since all the mountainous part of Derbyshire is in a similar state of confusion; that they have been disordered from a similar cause; and consequently all its *strata* must have had originally an uniform arrangement at the time lava was introduced between them.

This being granted, it will then follow, that the *strata* of grit and shale, which are now only found in broken detached masses, variously dispersed over the north part of Derbyshire, universally prevailed, or were superincumbent on limestone. And by parity of reason it will hold equally true, that the *strata* of argillaceous stone, clay, and coal, represented plate II. III. IV. were also universally incumbent on grit. Such I conceive to have been the original state and condition of the *strata* prior to the convulsion which threw them into their present state of disorder.

Having premised these matters, let us consider by what apparent cause lava could have been introduced between the limestone *strata*, at a time when they were compressed by such an immense incumbent weight of shale, grit, argillaceous stone, clay, and coal; and likewise shew why the lava did not burst open a passage and overflow the surface of the earth.

First, According to Chap. XII. subterraneous fire prevailed universally either in the same *stratum* or in

in the central part of the earth, as represented plate I. fig. 1.

Secondly, The expansive force of this fire elevated, and burst the incumbent *strata*, prior to the convulsion which threw them into their present state of confusion.

Fissures being thus opened over the melted matter, the violent pressure of the incumbent weight might cause it to ascend till it met with an obstruction superior to the impelling force.

Let us now suppose, for the present, that if the lava was thus circumstanced: it would consequently have a lateral pressure proportionable to the impelling force; and therefore might probably penetrate between the *strata*, and force its way, till it lost its fluidity by the coldness of the adjacent beds. Being thus extended to some distance, and passing over other fissures, it might fill them up more or less, as they happened to be more or less wide, and the lava more or less fluid.

Hence, I presume, the fissures in the Salterway mine being only in part filled up with lava, was owing to the above cause. See plate I. fig. 3, F F F, the lava.

Now since it appears that the shaft in Black Hillock mine, was sunk one hundred fathoms or 200 yards deep in lava, there is some probability that it flowed from the bowels of the earth, up that fissure, and spread itself laterally in all directions; and this conjecture is

strengthened by the various thicknesses of the same mass of matter at the different mines, laid down in the plan plate IV. fig. 2.

We have now to consider why the lava did not overflow the surface of the earth?

It has already been observed, that lava was introduced between the *strata* during their uniform arrangement, and whilst the beds of argillaceous stone, clay, coal, grit, and shale were universally incumbent on limestone.

Now it seems highly probable that shale, at so remote a period, was a soft, ductile substance, more subject to extension by an internal expansive force, than to crack or break, like the limestone, which was perfectly concreted: therefore since that *stratum* is one hundred and twenty yards thick, and was covered by a *stratum* of grit of the same thickness, and that grit by all the beds of argillaceous stone, &c. amounting to several hundred yards more; it seems highly probable, that the united resistance of so much incumbent weight, together with the quantity and quality of the shale, might totally obstruct the lava in its passage towards the surface, and cause it to spread laterally between the limestone *strata*.

Such are the conjectures which at present occur to me why the melted matter did not approach the surface

of the earth, according to the usual mode of volcanic operations.

Having now compleated my observations on the Derbyshire lava, and on the general state and condition of the *strata* productive of lead-ore, &c. I propose to enlarge my observation on the argillaceous *strata* productive of coal.

Plate II. fig. 1. represents a section of the *strata*, east and west of the river Derwent, from Belper-Ward towards Blackbrook. In this section, N° 1 dips or disappears at the river, and those of argillaceous stone, clay, and coal, become the superior beds, and are characterized accordingly. For instance, *a a a a a a* represent the argillaceous stone; *b b b b b* clay, bind, or clunch, synonymous terms; *c c c* coal. The upper *stratum* of argillaceous stone is excellent for the use of cutlers' grinding stones, and carpenters' whetstones. It is of a brownish colour, and may be observed in all the roads about Smalley, Heynor, Denby, Heage, Pentridge, Alfreton, Carnfield, Chesterfield, Sheffield, &c. It does not effervesce with acids, and as it has already been observed, when applied to the repair of roads soon returns to its primitive clay.

The lower *strata* are much harder, will strike fire with steel, and are more durable and fit for the business

ness of the roads. These beds are more white, and are commonly called crow-stone.

The beds of clay, clunch, or bind, are much indurated, and appear like stone, but soon dissolve by the weather.

All the above *strata*, incumbent on coal, whether argillaceous stone or clay, contain a great variety of vegetables, or the impressions of them; and particularly the Bamboo of India, striated and jointed at different distances; the *euphorbia* of the East-Indies, the American ferns, corn, grafts, and many other species of the vegetable kingdom, not known to exist in any part of the world in a living state. They are inclosed in the solid substance of stone and clay.

These vegetable forms, and the *strata* containing them, are a certain indication of coal, not only in Derbyshire, but in every part of this kingdom which I have visited: and I am informed, that the same appearances hold equally true in every other part of the world yet explored; of which some instances will hereafter appear.

Sir Ashton Lever's incomparable museum of natural curiosities, contains the most perfect specimens and the greatest variety of fossil vegetables, if I may be allowed to call them so, I ever saw.

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Now

Now since it appears that all *strata* accompanying coal, universally abound with vegetable forms, it seems to indicate that all coals were originally derived from the vegetables thus enveloped in the stone or clay: and we may say as much of the origin of iron; for the same *strata* also produce iron-stone, for wherever vegetables are observed to decay in stagnant ditches, the waters thereof appear ochory.

It is a matter worthy notice, that the superior *strata* contain iron-stone, coals and vegetable impressions, but **NO MARINE PRODUCTION WHATEVER.** And that the inferior *strata*, which are limestone, contain the *exuviae* of marine animals, but **NO VEGETABLE FORMS.**

Such is the arrangement of the *strata* in Derbyshire, so far as my observations have hitherto extended; and not only in Derbyshire, but in Staffordshire, Shropshire, Wales, and Ireland.

We have now related some general truths respecting the construction of the earth, or the arrangement of its *strata*, which may serve to point out the probability of coal or limestone being contained in the lower regions of the earth.

1. That the coarse millstone-grit, described page 182, is never incumbent on coal, but always incumbent on limestone.
2. That argillaceous-stone, clay, and coal, is always incumbent on grit.

Hence

Hence appears the necessity of constructing a museum composed of the different *strata*, and their various productions of animal, vegetable and mineral substances, arranged in the same order they are in the earth. This would convey a perfect idea of the bodies themselves, and shew us the order in which the respective *strata* were successively formed: for those containing marine productions only, must certainly have been formed whilst the sea covered the earth; and those containing vegetables, and no marine *exuviae*, must have been formed after the earth became habitable. It is therefore apparently repugnant to the general course of nature, that terrestrial animals and vegetables should be blended together with marine productions; we therefore consider the limestone *strata* as primitive beds, much anterior to the argillaceous *strata*, or coal; and likewise that all coal and iron, were originally derived from vegetation.

But indeed the *strata* have been so frequently deranged, that the order of nature is in some instances apparently inverted, and particularly in the following case.

“ In the whole city of Modena, and round about “ for some miles distance, in whatever place they dig, “ when they come to the depth of about sixty-three “ feet, they pierce the ground with a *terebra* or auger, about

“ about five feet deeper, and then the water springs up with so great force, that in a moment the well is filled up to the brim. This water is perpetual, doth not increase by rain, nor decrease by drought; and, what is yet more remarkable, from the surface of the ground to the depth of fourteen feet, they meet with nothing but rubbish and ruins of an ancient city. Being come to that depth, they found paved streets, artificers shops, floors of houses, and several pieces of inlaid-work.

“ It is very hard to conceive how the ground of this city was raised thus; we can attribute it to nothing else, but that it hath been ruined, and afterwards rebuilt upon its ruins; since it is not higher but rather lower still than all the adjacent country.

“ After these ruins they find a very solid earth, which one would think had never been removed; but a little lower they find it black and marshy, and full of briars. Signor Rammazzini went down one of these wells, and at the depth of twenty-four feet he found a heap of wheat intire; in another of twenty-six feet, he found filbert-trees, with their nuts. They found likewise every six feet alternately, a change of earth, sometimes white, with branches and leaves of trees of different sorts.

“ At the depth of twenty-eight feet, or thereabouts, “ they find a chalk that cuts very easy. It is mixed “ with shells of several sorts, and makes a bed of about “ eleven feet. After this they find a bed of marshy “ earth, of about two feet, mixed with rushes, leaves, “ and branches. After this bed comes another chalk “ bed of nearly the same thickness with the former, “ which ends at the depth of forty-two feet.

“ That is followed by another bed of marshy earth “ like the former. After which comes a new chalk “ bed, but thinner, which hath also a marshy bed un- “ derneath it. This ends at the place where the work- “ men bore with their auger. The bottom is sandy, “ mingled with a small gravel, in which they find seve- “ ral shells, such as are on the sea-shores.

“ These successive beds of marshy earth and chalk, “ are to be found in the same order, in whatever parts “ of the earth you dig. The augur sometimes finds “ great trees, which give the workmen much trouble. “ They see also, at some times at the bottom of these “ wells, great bones, coals, flints, and pieces of iron.”

Ray's Three Discourses, p. 223, 3d edition.

These alternate beds of marshy earth and chalk may possibly be considered as a contradiction to what has been observed concerning the general arrangement of the *strata*, viz. that all *strata* productive of vegetable impre-

impressions are superior to those containing marine *exuviae*. But the only inference apparently to be deduced from the *strata* at Modena is, that the superficial parts of the earth, have suffered frequent alterations from sea to land, and from land to sea ; and not that the *strata* in general were thus formed : therefore, such phenomena require a particular inspection before we can with propriety draw any conclusions from them respecting the general order of the *strata*.

We have one instance in Derbyshire, somewhat similar to the above ; namely, a *stratum* of ironstone, plentifully abounding with the shells of fish : therefore, as ironstone is generated in the argillaceous beds, and those beds are superincumbent on grit, shale, and limestone, these *exuviae* may also be considered as a manifest contradiction to the supposed general order ; but it is very easy to observe, that these shells are not marine productions, but of fresh-water lakes, rivers, &c. being actually the remains of horse muscles.

The above *stratum* of ironstone extends from Tupton Moor, near Wingerworth, the seat of Sir Henry Hunloke, Bart. to Stavely : it is about one foot thick, and lies about eight yards below the surface of the earth.

As a farther testimony of the general conformity of the *strata*, plate III. represents a section thereof at Lincoln Hill, near Colbrooke Dale, Shropshire.

N<sup>o</sup> 1.

N° 1, 1, 1, 1, *strata* of millstone-grit, similar to N° 1, in the Derbyshire *strata*. N° 3, limestone; P P, *strata* of quartz pebbles; a a a, argillaceous stone; b b, bind; c c, coal.

The *strata* about Colbrooke Dale have been strangely shattered to pieces, and thrown into great disorder, as appears by the section. Both the argillaceous *strata* and those of limestone abound with a great variety of figured stones, the former representing the vegetable kingdom, and the latter, those of marine animals.

Plate IV. fig. 1. represents a section of the *strata* from the new plantation in Chatsworth Old Park, to the river Derwent. N° 1, 2, 3, &c. shew the corresponding *strata* on each side a supposed great fissure; and likewise that although there is a *stratum* of coal in the Old Park, there is none in the plantation; owing to the disarrangement of the *strata*. These are the circumstances which render the practice of mining very uncertain, to those who do not attend to the quality of the upper *stratum*.

Though the fracture represented in the section, plate IV, is in no degree visible on the surface of the earth; yet since the arrangement of the *stratum* N° 1, is constantly inferior to that of coal; and also, that a *stratum* of coal has undoubtedly been discovered in the Old Park,

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it evidently follows that the *strata* have been fractured as represented.

Such therefore is the constant invariable arrangement of the *strata*, that whenever the *strata* accompanying coal are perforated down to N° 1, it is altogether in vain to proceed any further in search of coal; but particularly in Derbyshire, Staffordshire, and Shropshire, and also in Ireland, as will appear hereafter.

It is necessary to observe, that the sections representing the *strata* of argillaceous stone, clay, and coal, are not laid down by the same scale with those of limestone, &c. Twenty of the former being only equal in thickness to one of the latter; I have therefore taken the liberty of reducing their numbers, and increasing their thickness, in order to distinguish their different qualities by hatched lines.

Hence the following table is inserted; since nothing more is to be understood from the sections, than to represent the general arrangement of the *strata*, the ultimate end of subterraneous geography.

A TABLE

## A TABLE of the STRATA at ALRETON-COMMON.

Numb.		Feet.	Inches.
1	CLAY	7	0
2	RATCHELL, <i>fragments of stone</i>	9	0
3	BIND, <i>indurated clay</i>	13	4
4	STONE, <i>argillaceous concreted clay</i>	6	0
5	BIND	8	8
6	BIND	25	0
7	STONE, <i>a black colour</i>	5	0
8	BIND	2	0
9	STONE	2	0
10	BIND	5	0
11	BIND	3	0
12	COAL	1	6
13	BIND	1	6
14	STONE	23	0
15	STONE	14	0
16	BIND	7	0
17	SMUTT, <i>a black substance, resembling a stratum of coal-dust</i>	3	0
18	BIND	3	0
19	STONE	20	0
20	BIND	16	0
21	COAL	7	4
		184	4

## A TABLE of the STRATA at WEST-HALLAM.

Numb.		Feet.	Inches.
1	CLAY	7	6
2	BIND	48	0
3	SMUTT	1	6
4	CLUNCH, <i>indurated clay</i>	4	0
5	BIND	3	0
6	STONE	2	3
7	BIND	1	0
8	STONE	1	0
9	BIND	3	0
10	STONE	1	0
11	BIND	16	0
12	SHALE	2	0
13	BIND	12	0
14	SHALE	3	0
15	CLUNCH, <i>stone and sometimes cark</i>	54	0
16	SOFT COAL	4	0
17	CLAY	0	6
18	SOFT COAL	4	6
19	CLUNCH and BIND	21	0
20	COAL	1	0
21	BIND	1	0
22	Strong, broad-BIND	25	0
23	COAL	6	0
		222	3

Although the preceding observations have a tendency to prove that coal is not to be found under a *stratum* of limestone, yet we have an instance to the contrary at Etruria and Little Fenton, near Newcastle in Staffordshire, as follows :

First *stratum*, Ratchell, or fragments of stone.

Second, Limestone, one foot thick, which contains no figured stones.

Third, Sand.

Fourth, Argillaceous stone.

Fifth, Bind.

Sixth, Coal.

Here it may be necessary to observe, that all beds of sand and gravel are adventitious assemblages of matter, and not original *strata*, whence it appears, that the above *stratum* of limestone is a recent production, formed since the sea retired from that part of the earth, therefore not to be considered as interfering with the general order of the *strata*.

The following observations seem to shew, that gravel and sand are actually assemblages of adventitious matter.

1. The river Derwent flows from a gritstone *stratum*, and continues its course, ten or fifteen miles, at the foot

foot of gritstone mountains; throughout that space, the bed of the river, and its adjacent meadows, abound with rounded gritstones and sand, which is manifestly the granulated parts of the same *stratum*.

2. The river Wee continues its course many miles, through limestone vallies, until it falls into the Derwent at Rousley: therefore the bed of that river, and its adjacent grounds, where flat, contain limestones, chert, and other productions of the limestone *strata*, rounded by attrition, and also granules of the same *strata*.

Thus are the above rivers circumstanced down to Rousley, where they unite. From thence to the river Trent, the bed of the Derwent, and its adjacent meadows, contain rounded grit, limestone, spar, chert, and all the mineral substances Derbyshire produces, and likewise sand, as above.

Whence we may reasonably conclude, that all the above rounded stones and beds of sand, have been actually deposited by the river Derwent, however distant they may be found from its present course.

For instance: wherever a pit is dug in the meadows between Derby and Chaddesden Hill, the gravel is composed of such substances; and yet the channel of the river has been confined to its present situation nearly two thousand years: as appears by the remains of a bridge at Little Chester, said to have been constructed

by

by the Romans. This ancient ruin is now immersed a few feet in the river, more than it was forty years ago.

The same kind of gravel as above, I saw dug up at Osmaston, near the seat of Sir Robert Wilmot, Bart; the pit was about six feet deep: and also at Thurlstone, where a pit is now open for the repair of public roads: and yet both the above places are twenty or thirty feet above the level of the river Derwent, and nearly one mile distant.

These instances may serve to shew, that the above beds of gravel and sand are assemblages of adventitious matter, and not original *strata*. Hence we may conclude by analogy, that all beds of gravel wheresoever found, whether on mountains or in vallies, have been deposited either by rivers or the action of the sea, and that the stones which compose them were rounded by attrition, as the stones on a sea-beach, or in rivers.

A little observation would furnish innumerable instances of the same kind: I well remember seeing a gravel pit about a mile south of Uppingham, containing rounded lime-stones, sea-shells, and a *stratum* of sand and gravel. The limestone is similar to that of the Ketton-Quarry, which is peculiar for the figure of its granules which compose it, being spherical, and have much the appearance of the roes of fishes. The sand is manifestly composed of those granules, the grains be-

ing all of them spherical. Now from the various circumstances attending this gravel pit, as the rounded limestones great and small, rounded sea-shells, and sand; we cannot be a moment in doubt but this very pit must have been originally a sea beach, and that the sand is the pulverized parts of that stone.

The counties of Chester and Lancaster contain many beds of sand, which are occasionally dug up for the repair of roads and other purposes. These sand beds are frequently accompanied with a very curious phenomenon. At Mare, near the seat of Peter Brook, Esq.; I saw a sand pit, containing the fragments of pit-coal and cinders deposited in a stratified manner through a considerable extent of the bank. I have also observed the same appearances at Mobberley near Knutsford, and in the road from Walton-bridge to Worsley in Lancashire. In short, I scarcely remember ever inspecting a bank of sand that was totally free from extraneous bodies, or other evident marks of its having been deposited by the flowing of water. The above fragments of coal and cinders lay six or seven feet below the surface of the earth. And I have lately been informed by a Gentleman of that neighbourhood, that such appearances are not peculiar to the sand banks of Mare and Mobberley, but that they are almost universal wherever sand pits are dug in Cheshire.

Hence

Hence we may conclude that all beds of sand and gravel are assemblages of adventitious bodies and not original *strata*: therefore wherever sand or gravel form the surface of the earth, they conceal the original *strata*, and deprive us of the advantages of judging, whether coal or limestone are contained in the lower regions of the earth, and more especially in flat countries where the *strata* do not baffle.

In countries thus circumstanced, where coal or limestone are wanted, it is advisable to make a few experiments by digging, or boreing through the gravel or sand to ascertain the qualities of the *strata* underneath, whence we may infer with tolerable certainty what is contained below them.

It rarely happens that the argillaceous *strata* are covered by gravel or sand; but we have some instances of it, and therefore there may be many more of them in other parts.

At Nuttall near Nottingham, the beds of stone and clay are covered by sand and gravel five or six feet deep: therefore by viewing the surface of the earth, not the least appearance of coal can be discovered: this instance alone may serve to shew the propriety of experimentally proving the lower *strata*.

What has been observed concerning the origin of sand being the effects of attrition, is only to be understood in

a limited sense: for if we look upon an ancient stone edifice, it is easy to observe that the stone is much impaired or wasted by the weather, and particularly on the south-side, more than on the north, the former being more exposed to the sun, rain and wind than the latter.

And it has already been observed, that if we examine a stone quarry we shall find its upper surface decomposed as it were, by the operations of the weather, and reduced to grains of sand, which are continually washing down from the mountains and forming beds of sand in the vallies, rivers, and likewise in the sea.

Hence the origin of gold-dust on the banks of the African rivers, and the irony sands on the American shores.

Thus have the operations of the weather a constant tendency to restore the surface of the earth to its primitive order and regularity.

Having compleated my observations on the Derbyshire *strata*, I purpose giving some account of an extraordinary phenomenon which has frequently happened in Haycliff and Ladywash mines at Eyam; and in Oden mine at Castleton: the former are thus circumstanced.

1. The minerals are contained in the fissures of the limestone, N° 3, plate I. covered by a *stratum* of shale and

and grit, which retain their full thickness of sixty fathoms each.

2. The minerals contained in the above mines are blended together so as to produce the appearance of white Italian marble clouded with black, and are so extremely hard and compact as to require blasting with gunpowder, to separate them from the general mass.

3. Those in the Ladywash vein, are divided in two equal parts parallel to the sides of the fissure, as represented by the line  $\alpha$ ,  $\alpha$ , fig. 4. plate I. They may be compared to two slabs of marble, whose polished surfaces are absolutely in contact with each other without the least degree of cohesion.

4. These naturally polished surfaces are not truly flat, but in some degree waved, as if formed by a carpenter's plane, consisting of various members.

5. The two surfaces are generally coloured with lead ore, thinly laid on, as if only rubbed over with black-lead, though sometimes much thicker.

6. The vein in Haycliff mine contains two of the above seams, and therefore may be compared to three slabs of marble, the middle one polished on both sides and in contact with the other two. The separation of these slabs is represented by the two lines V, V, plate I. fig. 5.

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Thus

Thus are the above veins circumstanced: now what is yet more remarkable is this. If a sharp pointed pick is drawn down the vein with a small degree of force, the minerals begin to crackle, as sulphur excited to become electrical by rubbing; after this, in the space of two or three minutes, the solid mass of the minerals explodes with much violence, and the fragments fly out, as if blasted with gunpowder.

These effects have frequently happened, by which many workmen have been much wounded, but none killed, both in the Eyam mines and in that called Oden at Castleton.

In the year 1738 a prodigious explosion happened in the mine called Haycliff. The quantity of two hundred barrels of the above minerals were blown out at one blast, each barrel, I presume, contained no less than three or four hundred weight. At the same time a man was blown twelve fathoms perpendicular, and lodged upon a floor, or bunding, as the miners call it, in one of the shafts.

When the above explosion happened, the barrel, or tub, in which the minerals, &c. are raised to the surface, happened to hang over the engine-shaft, which is nearly seven feet diameter, and 448 yards distant from the forefield, or part, where the explosion happened; this barrel, though of considerable weight, was lifted

up

up in the hook on which it was suspended; and the people on the surface felt the ground shake, as by an earthquake.

Such are the effects which have frequently been produced in all the above mines; but from what cause they proceed I have not yet been able to discover, nor even the least traces towards it. The substance having been analized, is found to consist of fluor and the ore of lead, but the cause of explosion still remains equally mysterious, though some attempts have been made to obtain a knowledge of this curious phenomenon.

These curious observations I received from Mr. Mettam of Eyam, overseer of the mines, who also addressed the following account of them to Mr. George Tiffington of Winster, principal agent of the works.

“ SIR,

*Eyam, 2 July, 1768.*

“ I send you, by the bearer, two specimens of our  
“ *slickenfides*,\* containing all the variety of minerals  
“ where the explosions happen; they fly out in such  
“ *slappits*,† smooth on one side. The explosions are  
“ sometimes heard to the surface, and felt like an earth-  
“ quake; they frequently blow out all the candles in

\* *Slickenfides*, shining, as if polished by art, on one side.

† *Slappits*, fragments of the minerals burst out of the vein.

“ the

“ the mine, and split the *stemples* † into splinters as  
 “ small as the twigs of a birch beosom, to the distance  
 “ of thirty or forty yards from the *forefield*; § others  
 “ are broke, and some of them become too short and  
 “ drop out,

“ The smooth sides lie face to face, and have the  
 “ appearance of being shot with a plane, consisting of  
 “ various members. There is generally two of these  
 “ divisions in our forefield at Haycliff, about eight  
 “ or ten inches asunder, and a seam of white *kebble* ||  
 “ in the middle of that space, half an inch thick, in  
 “ which the miners rake down a sharp pointed pick  
 “ until the crackling ceaseth; then they run away,  
 “ knowing that the explosion will follow in a minute  
 “ or two. Sometimes a noise is heard like the beating  
 “ of a church clock, after which the greatest explo-  
 “ sions happen.

“ I am yours, &c.

To Mr. George Tiffington,  
 Winstor.

WILLIAM METTAM.”

† *Stemples*, joists laid across fissures, when the minerals are cut out, by way of making a floor, on which rubbish is deposited, to save the expence of raising it to the surface.

§ *Forefield*, that part of the vein under workmanship.

|| *Kebble*, a white opaque spar, calcarious, but not apt to break into rhomboidal forms.

In

In the above mines the workmen were much alarmed on the first of November 1755, about ten o'clock in the morning, the time of the earthquake so fatal to Lisbon. The rocks which surrounded them, were so much disturbed, that soil, &c. fell from their joints or fissures; and they likewise heard violent explosions, as it were of cannon. Being thus alarmed, they left their subterraneous employment and fled to the surface for safety. After some stay there and no visible alterations ensuing, their fears began to abate, when they ventured down again, and to their great surprize found that nothing material had happened in their absence. I have related these particulars, as small circumstances sometimes throw considerable lights on physical subjects.

In some of the mines near Winster, but more especially those at Alport, a mineral substance is raised, known by the name of *black-wad*. It is extremely friable, and when mixed with linseed oil, as if it were for levigating, it becomes ignited in the space of forty or fifty minutes. Its property of ignition was first discovered about the year 1750, by the late Mr. Richard Roe, of Derby, who happened to leave a quantity of it upon a levigating stone for the space of one hour; and when he returned found the whole heap on fire. Many experiments have lately been made by mixing

mixing this mineral with linseed oil, which produced similar effects. This substance is much esteemed by painters for its drying quality. It forms a sort of *stratum*, from one inch to several feet in thickness. The upper part of the *stratum* about half an inch thick, is a very fine yellow.

This singular substance has been lately analized with great precision, and found to consist of lead, manganese, iron, and some earth. See Philos. Transact. vol. 73, part 2d.

Mr. Stone of Alport, a principal proprietor of the above mineral, raises it for sale, on reasonable terms.

Gypsum, alabaster, or plaster of Paris, is likewise a production of Derbyshire. It is found in a *stratum* of marl near Chellaston, four miles south of Derby. It lies in large irregular nodulous masses, differing in colour, being variegated with reddish, blue, or greenish tints.

It is not laminated, but composed of granules like sugar. Some of it is a fine opaque white, equally as beautiful as statuary marble. It takes a good polish, and is much esteemed as a substitute for the finest marble, in the construction of monuments, and for interior ornamental purposes of buildings highly finished, being a durable substance, and much less expensive to work than marble.

Gypsum, much like the above, is likewise found in a *stratum* of marl near Newark in Nottinghamshire, and also near Tutbury in Staffordshire.

The modification of gypsum is very different in different places ; for instance,

At Clifton near Nottingham, it is perfectly stratified, the upper and lower surfaces being parallel to each other. This gypsum has also a fibrous texture, and its fibres are arranged at right angles between the upper and lower surfaces. Several *strata* of this species of gypsum, may be conveniently observed in a cliff near the river Trent, their thickness is variable, the greatest not more than three inches : its colour uniformly white, with some degree of transparency.

In various parts of Cheshire, gypsum is found in marl, laminated and transparent. The salt springs, and salt rock, are generally found in this calcarious earth.

The marl *stratum* in Cheshire, containing gypsum, is very thick ; I well remember a pit being dug 300 feet deep in that substance and not cut through. In what manner the plated gypsum is stratified I have not been able to observe.

Selenites, another species of gypsum, is found in the isle of Sheppey, in a *stratum* of argillaceous earth, containing nodules of ironstone and many extraneous bodies. It crystallizes in a peculiar form, very different from

the above ; and it is composed of thin transparent *laminae*, similar to talc.

All the various species of gypsum are applicable to many useful purposes ; namely, as cement to unite stone, and particularly the French burs, a silicious substance, more excellent for the purpose of grinding corn than any other yet discovered. It is likewise extremely useful as moulds for casting figures and other ornaments, and also as a proper substance for figures, and the ornaments themselves. It is also much esteemed for floors and other purposes.

Though I have already given some account in a former chapter, concerning the formation of minerals ; yet it may not be improper to extend those observations a little further before we conclude the present one.

The mountainous part of Derbyshire abounds with innumerable instances of minerals accumulating on the surface of limestone, in the fissures and cavernous parts thereof : wherein water impregnated with mineral substances constantly exudes, and evaporates, leaving the elementary principles to unite in select bodies according to their affinities, as lead-ore, spar, fluor, cauk, &c.

Hence it appears, that limestone is pervious to water, but by what peculiar operation it becomes thus saturated with mineral particles in its passage through the limestone *strata*, is not within my province to determine ; I only take upon me to relate the appearances which have

have so frequently occurred to my observation, in those subterraneous retreats.

The generation of minerals in Derbyshire is apparently confined to the limestone *strata*; grit, shale, toadstone, or channel, are not productive of minerals.

The above circumstances seem to evince, that the elementary principles which compose mineral bodies, are one of the component parts of the limestone *strata*, though they are never found in the solid substance of the stone.

Hence the limestone *strata* in Derbyshire are considered by the miners as the only beds productive of lead ore, though an instance or two have happened to the contrary: namely, lead ore in shale, in a mine called Shew engine at Eyam, and copper ore in considerable quantities in a mine near Grindon in Staffordshire, the property of John Sneyd Esq; of Belmont.

The above are the only instances which have hitherto occurred to me, of minerals being found in shale. The argillaceous *strata* therefore can only be considered as productive of iron and coal, &c. and not of the ores of copper, lead, or zinc.

But the quantity of minerals thus accumulating depend much on the quantity of water exuding from the surface of the stone: for where the quantity of water exuded is superior to the quantity exhaled, the minerals sus-

pended therein do not adhere together, but pass off with the current in circulation; and leave but little appearance of minerals behind.

Hence arise the various effects produced with respect to the quantity of minerals generated.

Such are the consequences arising from the circulation of water through the limestone *strata* in Derbyshire. And it is likewise evident that the fluids thus in circulation through the limestone, become impregnated with a variety of mineral particles at different periods of time, since they do not always deposit the same substance, but form alternate *lamineæ* of various minerals, as lead ore, cauk, spar, fluor, &c.

The *strata* of toadstone, or channel, we have already observed, is not productive of minerals, though its bladder holes are generally replete with spar; and some few instances have been discovered of spar being contained in its fissures.

The spar thus contained, implies, not only a solution of spar, but also that toadstone is pervious to water thus impregnated, descending from the incumbent *strata*: for wherever the toadstone baffles, or has no incumbent *stratum*, its bladder holes are totally void of all extraneous substances, which seems to indicate, that the spar contained in the bladder holes of toadstone proceed from a solution of spar in the limestone *strata* incumbent on toadstone.

The

The following operations of nature have lately been observed in a mine called Cross-Rake, situate in Matlock High-Tor, relative to the original formation of *lapis calaminaris*, or the ore of zinc: namely,

I have seen many instances of dog-tooth spar being so uniformly incrusted by calamine, as to preserve the true crystalline figure of the spar.

I have likewise seen many instances of the spar thus incrusted being wholly, or only in part decomposed and replaced by calamine, still retaining the external figure of the spar.

These facts manifestly imply that the vehicle containing the component parts of the above calamine must likewise contain some acid or dissolvent principle, whereby the calcarious matter becomes dissolved; and which seems to be the active principle whereby the particles of calamine become detached from the limestone which compose that mountain.

Hence we may venture to reason by the analogy between the veins of calamine in the lordship of Cromford, and those in the High-Tor at Matlock: for it is observable that the former principally abound with calamine, and not with spar; and likewise that lead ore is frequently inclosed in the calamine. Whence it is presumed that all such lead ore was originally inclosed in spar, the substance of which is become totally dissolved,

ved, or decomposed, as in the instance above, and the vacancy replaced by calamine. And we add to the above that there is a considerable analogy with respect to the appearance of the two minerals, viz. the calamine in Croft-Rake mine, and that in the mines at Cromford.

Besides the above, the *strata* in Derbyshire produce another species of lapis calaminaris, or ore of zinc, but recently known to be the ore of any metallic substance.

This mineral has been usually known by the names of black-jack, and mock-ore, from its similitude to lead ore, and from its not being known to contain any metallic substance whatever. The production, or the generating principles of this substance are not accompanied by any dissolvent menstrua like the former, being commonly united to a calcarious substance, consequently the latter must have been originally formed by a different combination of mineral substances, than that of the former.

I am not insensible that the above observations relative to the formation of minerals will appear very defective in the eyes of a practical chymist: therefore I only offer them as sundry appearances which have occurred in my subterraneous researches, and leave the cause of those effects to gentlemen conversant with such operations of nature.

Many more instances might have been added analogous to the former: but I hope the few observations which I have ventured to lay before the public, may serve to throw some light upon a subject, which is so extremely remote from our inspection, as the interior parts of the earth: therefore I shall only observe that these progressive operations of nature evidently corroborate the result of Chap. IV. for the incrustation of the dog-tooth spar is manifestly posterior to that of the spar itself

The crystals, known by the name of Buxton diamonds, are attended with the following peculiar circumstances; viz. They are not found in fissures, or caverns, of limestone *strata*; but in a *stratum* of yellowish clay, and likewise in a *stratum* of peat earth; the latter being incumbent on the former. Those found in the clay are pellucid and colourless, but those in the peat earth have a small tint of red, somewhat similar to that of garnets. They are of various magnitudes, from one tenth of an inch in length to that of five or six tenths. They have an hexagonal columnar form, and terminate with an hexagonal pyramid at each end.

Whether all the crystals thus found have a similar appearance as to colour, I am not certain; I only mean to say that all I have seen were so circumstanced.

As

As peat earth is a congeries of vegetable substances, which are well known to generate iron ; and as the various colours in stones are usually ascribed to metallic bodies ; the facts above related seem to corroborate the general opinion concerning the cause of coloured stones.

As these crystals terminate with a pyramid at each end of the column, it is evident their formation proceeds from a very different cause from those adhering to stone, and therefore seems to indicate that they were originally formed in the very *strata* wherein they are found.

I have only observed them in one particular part of Derbyshire ; namely, in some lands belonging to his Grace the Duke of Devonshire, situate about two miles south-west of Buxton ; now, or late in the occupation of Mr. Longdon.

I have been informed that crystalline bodies are also found in the fissures of the limestone *strata* near Tideswell, but these have only a form representing hexagonal pyramids, the bases whereof adhere to the limestone : hence it appears more probable, that the former were generated in clay and peat earth, as before supposed.

Rottenstone being accompanied with some singular and curious circumstances, which seem to have escaped the attention of curious inquirers into natural phenomena ; I am induced thereby to submit the following observations to the consideration and candour of the public,

as

as they have some tendency to shew the mutability of substances, considered as permanently durable.

First, Rottenstone is not stratified, nor generated in the fissures of the limestone *strata*, but is found as broken fragments of stone, imbeded in vegetable soil from the surface of the earth to the depth of 18 inches.

Secondly, It is accompanied with numerous nodules of chert, a silicious substance, generated in the limestone *strata*.

Chert and rottenstone being thus blended together, manifestly implies the dissolution of a limestone *stratum*, in which the chert was originally generated: and likewise that the rottenstone is nothing more than the fragments of limestone reduced to a calx.

Such are the appearances relative to rottenstone, and such the inferences thence deduced; whence it appears that limestone is a mutable substance.

The mutability of limestone is likewise evident on tops and sides of all limestone mountains; on the former, innumerable nodules of chert may be observed, as well as the broken fragments of those bodies, and particularly on that mountainous tract between Ashburn and Buxton, where pits have been dug for the repair of public roads.

Chert is observed to vary much in its colour, some of it being equally as black as the flint formed in chalk,

H h

others

others a lightish grey, similar to the colour of the limestone.

Many of these nodulous masses of chert, contain the fissures or impressions of *entrochii*, or screw like stones, which evidently shew that the *entrochii* existed anterior to the chert which inclosed them, though the remains of the animals are totally perished, and have left no other vestige behind but the figures or impressions of their external and internal forms, as monuments of their past existence.

The *entrochii* or screw stones, which so plentifully abound in the Derbyshire marble, being undoubtedly the remains of an animal not commonly known, though apparently one of the links which connect the animal and vegetable kingdoms ; I have endeavoured to collect some certain accounts concerning its mode of existence, and likewise of the *encrinus*, or *asteria*, another link which unites the animal and the vegetable kingdoms,

CHAP.

## C H A P. XVII.

*Of the Encrinus, Asteria, or Star-fish with a jointed Stem. And likewise of the Trochites, Entrochi, or Screw-stones, which so plentifully abound in the Limestone of Derbyshire, Staffordshire, &c.*

THE writers on Natural History have been much at a loss to discover to what species of animal those petrified bodies belonged, which are known to us by the various names of *encrini*, *asteria*, *astropodia*, star-stones, &c. and likewise those called *trochites*, *entrochi*, screw-stones, St. Cuthbert's heads, &c. which are commonly found in various parts of this kingdom.

Several species of the former have lately been found, recent, or in a living state, viz. one on the coast of Barbadoes, another on the coast of Martinico, and a third on the coast of Greenland. The first explains to what species of animal those fossils belong, called star-stones, *asteria*, *astropodia*, &c. the joints of the stem or *vertebra* having a similar form to the *asteria*, or star-stones.

H h 2

Fig.

Fig. 2. plate VII. represents the stem or *vertebra* of a recent *encriinus* taken on the coast of Barbadoes, with a part of its head, fingers or claws broken off, and is now in the curious cabinet of the late Dr. William Hunter. Its length is about fourteen inches, and its diameter above one third of an inch, diminishing a little towards the top. It is composed of pentagonal joints or *vertebra*, placed regularly one over the other, of a crustaceous substance, and united by thin cartilages, as appears by examining minutely the base of the lowest *vertebra*, where it is fastened to the starry indentures of the joint. This makes the *vertebra* capable of bending at the will of the animal in all directions.

If we examine the five furrows or channels along the stem, we shall discover a small hole between every *vertebra*; and in the center of the base of the lowest, where the stem is broke, is seen a small hole, which probably communicates through the middle of all the *vertebra* to the cavity in the center of the head.

Along this stem at different distances, from an inch and a quarter to a quarter of an inch in length, there are many circles of cylindrical jointed arms, five in each round, each series is of equal length and placed, much like the *quisitum*, or hore-tail plant.

Each arm is inserted into one of the five cavities of the *vertebra*, and its joints into one another, so that  
the

the upper end of one joint incloses the lower end of the next to it with a small margin.

These joints of the arms are generally about one twelfth of an inch in length, and the same in diameter, except a few near the insertion of the stem, which are shorter and thicker the nearer they are to it.

And here again we may plainly trace a small hole in the arms, passing through the midst of the joints, which communicates through the center of the starry *vertebra* in the main stem, with the hooked joint at the extremity of these arms.

On the under or inner side of these joints, that are near the end of the arms, we may discover four minute tubercles in every joint, two at each end; these are of the same crustaceous substance with the rest of the joint. By means of this uneven surface, together with the hook which the last joint forms, bending downwards, the animal can take a more secure hold of whatever it seizes.

But as the stem of this animal appears evidently to have been broken off short at the bottom, we must remain in doubt whether it moves about in the sea, or is fixed to rocks and shells by a base, like corals, sponges, or *keratophytons*, until some further discovery shall clear up this matter more to our satisfaction.

In

In examining the main stem, or column, we may observe some single joints or *vertebra* projecting a little further than the rest: there are generally three or four of these in each division. The angular parts of these joints end in small round knobs; but the knobs at the corners of the *vertebra*, immediately under the head of the animal, are remarkably larger than the rest.

The joints or *vertebra* of the stem vary in thickness as well as in diameter; the common thickness is about one tenth of an inch, but in the last four divisions approaching towards the head, they gradually diminish, till they become extremely thin.

We now come to what is called the head, which perhaps may be the body of the animal; for in the center of this dry specimen there still remains a cup of crustaceous substance, and of an oval form, about an inch in length, three quarters of an inch over, and a quarter of an inch deep; in the center of this, as was observed before, is a small hole, which apparently communicates with the internal part of the *vertebra* of the stem.

In this cup or cavity, it is probable were the intestines and stomach of the animal, as in that kind of *asteria* called *caput medusæ*. This cup is supported by the basis of six dichotomous testaceous arms or branches; perhaps five is the natural number, for one seems irregularly

gularly placed. These lower parts or bases of the branching arms consist of three joints each, and surround the cup to which they seem united; each of these divide into two other jointed branches, that are round or cylindrical on the under sides, but flattish on the upper or exterior side, with a deep groove running along the middle, which is furnished with two rows of suckers. From the upper edges of each alternate joint of these branches arise two rows of small jointed claws, like fingers, and these two opposite rows bend towards each other. Each small branch or finger is about half an inch long, and one twentieth of an inch broad. The size of these points diminish gradually towards the last joint, which ends in a point. Each of these joints is concave at the lower end, into which is inserted the convex end of the joint below. With these joints, claws, or fingers, they secure their prey.

As the finer and more subdivided branches, claws, or fingers, were broken off from the head of the recent specimen above described, I have given the representation of a curious petrified head found at Pryton-passage in Gloucestershire, in order to convey a more perfect idea of the living animal.

Fig. 1. plate VII. shews all the ramified arms of the head closed up together.

Fig. 3, 4, 5, represent fragments of the stem usually called star-stones.

The arms of this animal, which are inserted into the stem, are said to drop off, take root, or fix themselves to the rocks, where they grow up to full maturity; the usual mode in which the species propagate.

The *entrochi*, or screw-stones, which so plentifully abound in the limestone *strata* in Derbyshire and Staffordshire, are said to be the remains of a marine animal, of the same genus with that above described, though of a very different species. Fig. 6. represents the head of the species called *lilium capidium*, with part of its stem adhhereing, jointed and cylindrical, having a cavity in the central part. These stems are said to have been originally crustaceous, and united by cartilages like the *vertebra* of the *encrinus*; and like that animal, have been surrounded with arms, but not in the same order, which drop off from the stem, and grow as the former. The arms, together with the fragments of the stem, or pedicle, accompany each other in the Derbyshire marble, and the very spots where the insertions have been made upon the stem, are obvious on the least inspection of the fossil *entrochi*. Fig. 8 and 9. represent two joints of the stem or *vertebra*, usually called *entrochi*, screw-stones, St. Cuthbert's bead, &c. Fig. 6. A B, is faithfully copied from a petrified animal in the curious cabinet

cabinet of John Hunter Esq; Leicester-fields. Fig. 7. G, D, shews a continuation of the stem or *vertebra* as supposed to be growing, or fixed upon a rock; that being its natural situation, it is therefore added to convey a more perfect idea of its history. The fragments I have frequently observed in the Derbyshire marble, and the various accounts communicated to me from several Gentlemen eminent in that branch of natural history, corroborate the above conjectures.

They are said to grow or remain unalterably fixed upon rocks in the bottom of the Sea, though not any of them have hitherto been found recent or in a living state in any part of the world.

The locality of their situation seems to denominate them one of the links which unite the animal and the vegetable kingdoms in one continued chain of beings.

Amongst the various marine productions contained in the Derbyshire *strata*, I have not seen any *asteria*; but I have observed many of them intermixed with soil near Staunton House, situate in the most southerly part of Nottinghamshire: they are to be found in the soil which composes the banks of ditches and rivulets; whence it may be inferred, that Staunton was originally their native climate, though they now inhabit the West Indian seas.

The preceding accounts relative to the *encrinus* are principally borrowed from the Phil. Trans. vol. 52.

## C H A P. XVIII.

*Of the Strata in North Wales.*

THE limestone *strata*, of which Holkin mountain is composed, are productive of minerals similar to those in Derbyshire; namely, lead ore, and the ore of zinc, or lapis calaminaris. And the argillaceous *strata* at Bagilt, are productive of vegetable impressions, viz. of the Bamboo, and other species. And they are likewise accompanied with several *strata* of coal, arranged according to the following table and section annexed. See plate V. fig. 2.

## TABLE of the STRATA at BAGILT.

Numb.		Feet. Inches.
1	GRAVEL, SAND, and other adventitious matter	45 0
2	SHALE	9 0
3	FREESTONE, argillaceous	6 0
4	SHALE, though not generally	1 0
5	COAL	

Numb.		Feet. Inches.
5	COAL	6 0
6	CLAY	9 0
7	FREESTONE, <i>argillaceous</i>	44 0
8	COAL	2 3
9	FREESTONE	90 0
10	SHALE	15 0
11	COAL	15 0
12	CLAY	12 0
13	SHALE	6 0
14	FREESTONE	1 6
15	CLAY, <i>much indurated</i>	9 0
16	SHALE	9 0
17	BLACKISH STONE, <i>containing the</i> <i>shells of fish</i>	1 0
18	COAL	9 0
19	SHALE	1 0
20	CLAY, <i>or Bind</i>	20 0
21	FREESTONE	40 0
22	COAL	5 0

Hence it appears that the *strata* at Bagilt, are similar to those accompanying coal in Derbyshire, Staffordshire, Shropshire, Leicestershire, and likewise to those in all parts of England hitherto explored.

I i 2

This

This general uniformity of measures accompanying coal renders the indications of that substance the more probable, which is my principal object for giving a section thereof, and also for inserting the above table.

In many other parts of North Wales the *strata* are quartzose, or whinstone; a substance similar to rounded pebbles and boulders, observed in the gravel and sand pits in Cheshire, and other parts of England, where no such *strata* appear: this circumstance seems to confirm our conjectures concerning the origin of rounded stones, see page 215, viz. that their forms are owing to attrition, or rolling upon a sea beach, as will evidently appear by observing the effects produced by the fluctuations of the sea on the British shores, &c.

The shells observed in *stratum* N° 17, evidently shew, that the formation of the incumbent *strata*, are more recent than the shells, or the *stratum* thus covered: therefore a farther testimony of the progressive operations of nature.

CHAP.

## C H A P. XIX.

*Observations on the Strata in the North of Ireland,  
particularly on the Giants Causeway,*

AT Gorestown in the county of Armaigh, two shafts were lately sunk, in hopes of discovering a *stratum* of coal, but without success; I was therefore induced to examine the hillocks, in order to observe whether there was any probability of coal in the lower *strata*; and found the substances which composed the hillocks as follow, viz. a lightish blue calcarious shale, intermixed with marine shells, *entrochi*, &c. and likewise with some nodules of ironstone, in which were also inclosed fragments of shells retaining their native testaceous matter. The shale also contained many fragments of limestone in which sea shells are inserted.

These singular appearances induced me to consider the shale as a *stratum* of decomposed limestone, and therefore unfavourable to the presence of coal, as having no analogy to the indications of coal in England.

A few

A few days after I visited Drumglass colliery, where I found the *strata* accompanying coal perfectly analogous to those in the English collieries, viz.

		Feet. Inches.
1	Clay and Rubble stones	48 0
2	Soft argillaceous stone	30 0
3	Bind, or argillaceous clay	35 0
4	Shale	15 0
5	Coal	4 6
6	Argillaceous stone not cut through	<hr/>
		142 6

Now since the *stratum* N° 6, is not cut through, it may be necessary to observe, that there is some probability of a *stratum* of coal underneath it; therefore it is requisite to ascertain the truth thereof experimentally.

In a mountain north-east of Moneymore, I observed a *stratum* of white limestone, so similar in appearance to a *stratum* of chalk, that I had every reason to suppose it a chalk *stratum*, fully concreted, or become a perfect limestone. I likewise observed a *stratum* similar to the above at Dunloose Castle, on the north coast of Ireland, containing an immense quantity of chert, and some few marine shells of the belemnite kind.

In the vicinity of Maghera, I observed many fragments of lavas, and also of bluish quartzose stone (called whin-

whinstone), scattered plentifully over the lands, but many more of the latter than the former ; however, the former seemed to increase in number on the road to Garvah, and still more in the neighbourhood of Coleraine.

Two miles north of that town, on the road to Port-Rush-Strand, lies a *stratum* of lava : a pit having been dug therein seven or eight feet deep, to obtain materials for the purpose of repairing the adjacent road, afforded a convenient opportunity of examining the several phenomena relative to that volcanic matter.

1. The upper part of the *stratum* was become totally decomposed and reduced to vegetable soil, though it still contained its original colour, that of a very dark brown.

2. The soil was succeeded by small fragments of lava, the magnitude whereof increased downwards to the bottom of the pit, where the *stratum* became nearly of one solid mass : an effect commonly produced upon other substances or kinds of stone.

3. This lava contains many bladder holes, either wholly or in part filled up with zeolite, a substance rarely found in England.

4. In some of the holes which are not completely filled up, may be observed the crystallized figure of the zeolite, namely cubical, very similar to that of fluor.

5. These crystallized bodies likewise shew, that they were not inclosed in the lava whilst it was liquid fire, but subsequent to that event; having been evidently exuded through the substance of the lava: consequently lava seems equally as pervious to a solution of zeolite, as toadstone or limestone is to a solution of mineral substances.

Zeolite has much the appearance of fluor, both as to colour, figure, transparency, and hardness. And it has also somewhat the same chemical properties, for it will not effervesce with acids: but I have been informed by an eminent chymist, that it is nevertheless soluble by acids.

The great analogy between the colour of the soil near Coleraine, and the parts adjacent, seem to indicate that a vast torrent of lava has flowed from the north of Ireland, southward. Since it may be presumed, that similar appearances have arose from similar causes, viz. decomposed lava. Therefore, since the colour extends to the distance of twenty or thirty miles towards the south, and nearly as far east and west, we may thence infer, what an extensive tract of ground has been covered by liquid fire: namely, twenty or thirty miles from north to south, and nearly as far from west towards the east, where it terminates at Balley Castle, upon a *stratum* of white limestone, and at which place the mea-

measures totally change to different denomination, viz. argillaceous stone, clay, and coal. See plate VI. fig. 2. in which the arrangement of the *strata* are represented.

Port-Rush-Strand exhibits an awful wreck of the terraqueous globe, consisting altogether of immense masses of black lava; so extremely replete with bladder holes, and so void of extraneous matter, that it perfectly resembles the *scoria* of iron, and therefore leaves not the least doubt of its being a volcanic production.

This stupendous cliff is situated on the verge of the Atlantic ocean, eight miles north of Coleraine, and four miles west of the Giants Causeway, Irish measure, three of which are nearly equal to five English miles.

The same appearances extend towards the west; we therefore presume they are also composed of similar substances; and it is easy to observe a continuation of the lava from Port-Rush-Strand, to the Giants Causeway, and from thence to Balley Castle, a distance nearly equal to fifteen English miles east of Port-Rush.

The Giants Causeway is situated at the foot of a stupendous cliff, the elevation whereof is not apparently less than five or six hundred feet perpendicular above the Atlantic ocean: and yet the whole of this cliff consists of one intire mass, composed of different *strata* of lava; for it is not apparently the effects of one eruption, but of many successive convulsions.

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The substance of the lava of which that immense cliff A, plate VI. fig. 1. is composed, is much impaired by length of time, and the usual operations of the weather; insomuch that large masses thereof become detached daily, and fall into the sea: whence we may reasonably infer, that the cliff originally projected much further towards the sea than at present, but to what extent is very uncertain; however, if we consider the immensity of time elapsed since the cliff was formed, it is not very improbable to suppose, that it might have extended much further than the basalt columns now do.

The cliff also exhibits many columnar appearances, though very rude and shapeless, compared to those in the causeway, except in a very few instances. And as the cliff C, exhibits a similar appearance to that of the cliff A, and as the colour of the intermediate soil is likewise similar to that of decomposed lava, we may thence infer a continuation of that substance from A to C, though several miles distant from each other.

Plate VI. fig. 1. represents a transverse section of the mountain and the Giants Causeway. A the cliff, B the causeway.

There are some faint traces in the cliff, which seem to indicate that the whole of the mountain was not formed by one, but by several successive eruptions, as represented

fented in the section, and likewise, that the columns extend under the cliff towards E, as shewn in the plate. These observations are only introduced as objects worthy the attention of those, who may be desirous of exploring the various phenomena relative to these magnificent works of nature, and not as matters of fact absolutely existing, but as probable truths.

At the foot of the cliff among the fragments of lava, I found a piece of iron ore, similar in appearance to the Cumberland ore, vitrified on one side, which is some testimony of the cause whereby some lavas may be magnetical, and likewise that the substances supposed to be lava, have also been in a state of fusion.

The columns B, E, are in a vertical position, and of various diameters, from fifteen to twenty inches, and some of them thirty feet long. They seem to be all of them prismatical, or equally thick from end to end, though they consist of various unequal sided figures, viz. pentagonal, hexagonal, heptagonal, and probably many other forms.

Each column is apparently divided into unequal parts, by means of transverse joints, but many bisect the columns partially, leaving five or six inches of the central part solid. In some instances the joints extend quite through the columns, but they have originally

united, and probably separated by water lodging and freezing in them.

The articulations are not flat, but convex and concave, exactly fitted together, but not in any order with respect to the convexity or the concavity being upwards or downwards; for in many instances they have been observed in both directions.

The columns have one uniform colour, namely, a dark brown approaching towards black, and of one uniform density and quality, apparently quite free from bladder holes, notwithstanding the cliff is replete with them: therefore since it appears that these basalt columns are of one uniform substance, and have assumed a variety of prismatic appearances, not only in Ireland, but also in many other parts of Europe: the presumption is great, that their various forms are not owing to any property of crystallization, since it is universally allowed that similar substances under similar circumstances invariably assume similar figures.

Hence it appears that the formation of basalt must arise from a different cause. But to what cause their forms may be owing remains to be ascertained, and probably may remain a secret after every possible effort has been made to investigate the true cause thereof.

However difficult the problem may appear, let us endeavour to give the best solution we can, since we are

are not likely to render the subject more obscure by the attempt.

According to the preceding conjectures, the columnar bodies of which the Giants Causeway is composed, were originally in the very heart of the mountain, and were also in a state of fusion, in which state it seems highly probable that they composed one uniform mass of liquid fire, more perfectly fluid than the incumbent *scoria*; or perhaps much more so than melted iron is to its incumbent dross.

If the columns were thus in a state of perfect fusion, and thus protected by *scoria* from the external cold, may we not thence infer, that its contraction in cooling from such an immense degree of heat, to its present temperature must have been very considerable, and also very gradual? And therefore since similar appearances have been produced from a cause somewhat similar to the above, namely, a contraction from wet to dry, as in the instance of the *ludus helmontii*; we may thence infer by analogy, that basalt columns were formed by contraction, from an extreme degree of heat to that of their present temperature. However, such are the conjectures which have hitherto occurred to me concerning the origin of basaltes.

Among the many curious and interesting observations communicated to the world by that ingenious mineral-

logist, Mr. E. Raspe, on the subject of extinguished volcanos, it appears that basalt is commonly found in the vicinity of them, which is a considerable testimony of its being a volcanic production.

And the learned naturalist M. Faujas, has likewise favoured the public with an excellent Treatise on the same subject, containing many instances of basaltes being absolutely a part of the matter which flowed from a volcano in a state of liquid fire, which evidently appear, from the same mass of lava situated near its crater, being wholly and in part columnar. This learned Gentleman likewise observes, that in some of the corresponding faces of these prismatic columns, are inserted fragments of granite which were evidently broke and separated by the contraction of the lava in cooling, a portion of the granite remaining in each of the corresponding faces.

A little observation, says the author, on the cause-way at Bridon Bridge, will satisfy the most inquisitive naturalist, that the prifnatic columns which compose it are placed in a vertical position, and in the finest order, and are separated from each other by interstices about five or six lines, or half an inch in width. And it is easy to observe that the lava of which this causeway is composed, has not been removed by any accidental cause, but remains where it was originally deposited :  
there-

therefore no one can ascribe the disjunction of these columnar bodies to any other cause but that of contraction by cooling.

M. Faujas likewise observes, that these prismatic columns have a diversity of figures, viz. triangular, quadrangular, pentangular, hexangular, heptangular, and octangular.

Consequently this great variety of figures is a further testimony that their columnar forms are not owing to crystallization.

That basaltes is lava is also evident from the observations of the Rev. Dr. Trol, in his tour through Iceland: for this great island is allowed to be composed principally of lava, and yet various parts thereof plentifully abound with basalt columns of various figures and dimensions.

After so many corroborating testimonies tending to prove the origin of basaltes, nothing more is requisite to ascertain the fact, but that of being an eye-witness to the operation itself; yet as the subject has been so much controverted, it may not be improper to add the observations of Mr. Hodges, in his late tour through India, in the line of his profession: viz. That a cliff called Moutagena, is wholly composed of basaltes; and that under the cliff, is a spacious extensive cavern, which

which he thoroughly examined by the aid of torches, and observed the same columnar appearances as on the exterior parts thereof, and likewise that charcoal was imbeded in the solid substance of the stone throughout the whole extent of the cavern.

The singular appearances accompanying the above columnar bodies, with respect to charcoal being imbeded in the solid substance of the stone, seems to have been an effect produced at a time while that matter was liquid fire. That circumstance being duly considered, together with the durability of charcoal, leaves little room to doubt the origin of the substance in which the charcoal, or burnt wood is inclosed.

But notwithstanding the preceding observations have some tendency to unfold the original cause of basaltes, some doubts may nevertheless arise, with respect to the origin of the Giants Causeway, and its adjacent mountain, since no visible crater, nor the least vestige of an extinguished volcano are now remaining, except the substances before mentioned, from whence such immense torrents could have flowed, as are now spread over so great a part of the north of Ireland.

These circumstances render it necessary to observe, that whoever attentively views and considers these romantic cliffs, together with the exterior appearances of that

that mountainous cliff, will I presume soon discover sufficient cause to conclude, that the crater from whence that melted matter flowed, together with an immense tract of land towards the north, have been absolutely sunk and swallowed up into the earth, at some remote period of time, and became the bottom of the Atlantic ocean. A period indeed much beyond the reach of any historical monument, or even of tradition itself.

But though it does not appear, that any human testimony, or record, has been handed down to us concerning such a tremendous event; yet the history of that fatal catastrophe is faithfully recorded in the book of nature, and in language and characters equally intelligible to all nations, therefore will not admit of a misinterpretation; I mean those stupendous cliffs which environ a part of the Atlantic ocean.

These are characters which cannot mislead, or divert our attention from the true cause thereof; and we may further add, as a collateral testimony, that subterraneous fires have frequently burst open the bottom of that ocean in various parts, and have formed new islands of considerable magnitude: whence it is evident that the same cause still exists, and produces similar effects. I say, the consideration of such disasters; together with that of the cause still subsisting under

the bottom of that immense ocean, almost persuade me to conclude that Ireland was originally a part of the island Atlantis, which, according to Plato's Timæus, was totally swallowed up by a prodigious earthquake, in the space of one day and night, with all its inhabitants, and a numerous host of warlike people, who had subdued a great part of the known world.

The history whereof, is quoted by Dr. Hooke, in his Posthumous Work, to the following purport; viz. Solan being at Saim in Egypt, when Amasis was king, inquired of those priests who were most conversant with history, what they knew concerning the antiquity of Greece, or Athens, and was answered by one of the senior priests, as follows:

Many wonderful actions of your city are recorded in our monuments, but particularly one for greatness and virtue exceeds all the rest; namely, that both Greece and Egypt were invaded by a numerous army of warlike people from the island Atlantis: an immense island, situate where the Atlantic ocean now flows, and governed by several powerful kings, who not only ruled over the whole of that island, but several others, and likewise over a great part of the continent. The united force of these kings invaded both Greece and Egypt, and were bravely repulsed and driven to their

their native island, which, immediately after their return was totally swallowed up into the bowels of the earth, with all its numerous inhabitants, in one day and night by a prodigious earthquake and inundation of water. See Dr. Hooke's Post. Work, p. 373.

Such is the substance of the history related by Plato, and quoted by Dr. Hooke. But whether such an island as Atlantis ever existed, and was thus overwhelmed, may still remain doubtful, though similar events, but of less magnitude, have frequently happened in various parts of the world; therefore since such events are not repugnant to the operations of nature, it is not improbable but the preceding observations, and also the Platonic history, may have some foundation in nature. But these remarks are rather a digression from the subject, therefore to return.

I have already observed that the lava extends from Port-Rush-Strand, to the Giants Causeway, and from thence to Balley Castle, where it finally terminates upon a *stratum* of white limestone: and where a new arrangement of *strata* commence, quite of a contrary nature, as represented in plate VI, fig. 2. B, the lava, L, the white limestone.

Two miles east of Balley Castle, the following *strata* commence. See plate V.

- 1 WHINSTONE, a quartzose substance, which strikes fire with steel.
- 2 FIRESTONE, argillaceous.
- 3 TILL, SHALE, or laminated clay.
- 4 STONE, argillaceous.
- 5 TILL, or SHALE.
- 6 FREESTONE, argillaceous.
- 7 COAL, four feet six inches thick.
- 8 STONE, argillaceous.
- 9 TILL, or SHALE.
- 10 LIMESTONE, brown, containing no marine shells.
- 11 BIND, indurated clay.
- 12 STONE, argillaceous.
- 13 STRATA, not ascertained.
- 14 MILLSTONE GRIT, containing quartz pebbles.

This stratum is perfectly similar to stratum N° 1, in the Derbyshire sections.

Plate V, fig. 1. represents a transverse section of the mountain; L L, a drift or road into the mountain, for the purpose of conveying coals to the wharf.

The sections plate V and VI, are particularly recommended to the reader's consideration, as matters of some importance tending to the discovery of coal.

The section plate VI, fig. 2. affords a convenient opportunity of comparing the lava and whinstone,

which in some few instances are so similar as to render them not easily distinguishable from each other.

The arrangement of the *strata* two miles east of Bally Castle, is in part obtained from my own observations, and in part from several experienced workmen, employed in raising stone from the above *strata*, which is of a tolerable good quality and colour, fit for buildings, and conveniently situated for water carriage.

The *stratum* N° 14, is totally covered by the sea at high water; it is situated below the quarries, and requires some attention to discover it.

Here it may be necessary to observe, that as the above *stratum* of whinstone incumbent on coal is the only instance of the kind which has hitherto occurred in the course of my observations, it may serve to shew, the necessity of ascertaining the arrangement of the *strata* in many parts of the world, in order to obtain a more competent knowledge of the general construction of the earth. For if I had not previously observed a *stratum* of whinstone situated as above described, I should not have considered that stone to have been arranged with the coal *strata* in any part of the world: therefore let it be remembered that in subjects of subterraneous geography we can only reason by the analogy which one part of nature bears to another.

But

But having once observed a notorious instance of whinstone being incumbent on coal in one part of Ireland, we may thence infer, that it may likewise be incumbent on coal in other parts of that kingdom; but more especially so, in the vicinity of the colliery before described: for such is the regularity in the arrangement of the *strata*, that coal certainly lies beneath the whinstone, and all the other beds of stone and clay in that neighbourhood.

But notwithstanding whinstone may be considered as a certain indication of coal in the county of Antrim, yet it is not to be understood that it is universally incumbent on coal, in every other part of Ireland: for, according to the general appearances on the surface of the earth, the *strata* thereof seem to have been thrown into as much disorder by subterraneous convulsions, as the *strata* in England. And therefore, by parity of reason, it may be inferred that similar effects have been produced in the former as have taken place in the latter.

Therefore since there are many notorious instances in Derbyshire, wherein the upper *strata* have disappeared, as before described; so in like manner the upper *strata* in Ireland may likewise have been removed by a similar cause.

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Therefore it becomes essentially necessary to know the appearances of all the *strata* beneath the whinstone; since that *stratum* may be totally removed, and the others, or at least a part of them remain; any one of which become as certainly an indication of coal, as if the whole arrangement was complete, as represented in the sections plate V, or VI. The observations given of the Derbyshire *strata*, may render any further account of these matters unnecessary; therefore I shall only observe, that specimens of each *stratum* of stone, clay, &c. numbered according to the above arrangement, or in the order they lie in the earth, will be an infallible guide in such researches; and it is also required to record the thickness of each *stratum*; for by that means the depth of the coal may be truly ascertained.

And it may be convenient further to observe, that as the *strata* in Ireland have been apparently thrown into as much confusion as those in England and Wales, it seems highly probable that the former may bafflet, or appear near the surface of the earth, as well as those in the latter: therefore, by exploring the cliffs, both coals and minerals, or the indications thereof, may be observed so as to facilitate the discovery of those substances.

And

And let it be remembered, that the impressions of vegetables in stone or clay is a particular indication of coal in the lower *strata*.

With respect to minerals, no such rules are strictly to be regarded ; for experience shews that they are produced in *strata* of different denominations : namely, in Derbyshire and Staffordshire, lead and copper ores are generally produced in the fissures, and between the *lamina* of the limestone *strata*. And we have one singular instance of copper ore being found in a *stratum* of shale near Leek, in a mine belonging to John Sneyde, Esq. But shale is not to be considered in any degree as productive of minerals.

At Kady in the county of Armaigh, a tolerable vein of lead ore has been discovered in a *stratum* of whinstone ; but the quantity of water flowing into the mine renders the work of little value.

Here it may be convenient to observe, that since whinstone is incumbent on coal at Bally Castle, it may probably be so too at Kady, and elsewhere.

Amongst the numerous phenomena exhibited in various parts of Ireland, I presume there are but few more conspicuous, or more instructive, in matters relative to the antiquity of arts, and the state of civilization in that country, than the following.

First,

First, Ireland plentifully abounds with peat grounds of considerable depth, a substance well known to arise from a luxuriant vegetation, and from no other cause.

Secondly, These peat grounds are plentifully stored with fossil wood; namely, large and small trees, retaining their fibrous roots; and these trees lie in every possible direction, as if they had floated in water, and left as above described: for their fibrous roots and their situations evidently shew that they never grew in the earth which now incloses them. Thus are the generality of peat grounds circumstanced, both in England and Ireland.

Thirdly, I have been informed that there are several instances where the bog earth and the fossil wood have been totally cut up, and cleared from off the ground upon which the bog originally began to accumulate; and that the land so cleared was observed to lie in ridge and furrow: whence we may infer, that these lands were actually ploughed prior to the wood being laid thereon; for the form of the ground cannot be ascribed to any other cause but that of ploughing.

If the above phenomena are granted as matters of fact, the following question will probably arise: namely, by what means was the wood thus scattered over the arable lands? To which we reply, not by the hands of men, nor by a tempest, but by a vast deluge

of water, which probably overflowed the greatest part of Europe ; since similar instances are very common in various parts of England, of which I have frequently been an eye-witness.

But it is not ploughed grounds alone which indicate a state of civilization and arts, prior to that event ; remains of arts have also been discovered by the above means, namely, fire-hearths, fences, and the remains of buildings.

And in the year 1692, as some workmen were cutting peat earth for fuel in Tipperary, ten feet below the surface they found a cap or crown of gold, weighing five ounces, curiously wrought; See *Archæologia*, vol. 7. p. 103.

The ploughed grounds, fire-hearths, fences, &c. evidently shew that all such places were originally the surface of the earth ; and the quantity of peat earth accumulated thereon, manifestly implies that the kingdom of Ireland was totally depopulated, and remained desolate a considerable space of time, previous to its being inhabited again. For it seems reasonable to suppose, that if the owners, or the occupiers of the lands, thus covered by wood, had survived the cause of that event, they would rather have preferred the removal of the wood from their ploughed lands, than that of clearing uncultivated lands of growing wood, for the

pur-

purpose of tillage: therefore, since so much wood was suffered to remain upon cultivated lands, we may thence infer, that neither the owners nor the occupiers thereof survived the dreadful catastrophe.

Whether this great revolution can with more propriety be attributed to the deluge of Noah, or Ducaslion, is not a matter of much importance; that it was occasioned by an immense flood is apparently evident, from the effects produced; since no other cause in nature, yet known, could have separated trees from the earth with all their fibrous roots, and have assembled them together in the order above described.

And these conjectures are rendered the more probable, when we consider the vast quantities of lava on the north coast of Ireland; for the former and the latter arise from one and the same cause, as already observed Chap. XII.

But the above are not the only marks of desolation occasioned by that tremendous convulsion; for the remains of the moose-deer, and other animals, which are so frequently found at the bottom of the peat earth, may likewise be considered as victims of the same cause.

Therefore from all the various circumstances relative to the present state of Ireland, we may infer, that arts and civilization had made a considerable progress in

that kingdom prior to the above tremendous event ; that it was totally depopulated, and remained quite desolate very many centuries before it was repeopled : for it is well known that peat earth is generated from vegetable matter, and that the branches of trees lying upon the earth occasion a luxuriant vegetation, and especially in places favourable to retain some water : hence we presume that peat earth was originally generated by means of wood thus assembled together, and remaining undisturbed on the surface of the earth many hundreds, or perhaps thousands of years. Thus in process of time the constant accumulation of vegetable substances of various kinds were formed into peat earth, and became an excellent fuel : and the immense quantity of fir timber entombed in the peat earth, seems to have contributed a considerable quantity of bituminous matter to the generality of that substance.

Hence peat earth, containing fossil wood, circumstanced as above described, may be considered as some certain testimony of the great revolutions which the earth has undergone, and probably at different periods of time. Therefore it is not Ireland alone which exhibits evident marks of devastation on the surface of the earth, but Great Britain likewise ; for many parts of this kingdom abound with fossil wood, and particularly Cheshire, Lancashire, and Yorkshire. For instance :

Twelve

Twelve miles below York, at Youle, ploughed lands have been discovered under the following *strata*,

- 1 Rich firm soil
- 2 Sand
- 3 Boggy earth, containing fossil wood.

Under the peat earth the ground was firm, and lying ridge and furrow. Lowthorp's Abridg. vol. 2, p. 424.

And I have been informed that lands have been discovered in the same state, under a part of Tatmoss in Lancashire, which was cut away for fuel.

Much fossil wood is also found in peat earth near Congleton in Cheshire, attended with the following remarkable circumstances, viz.

The trunks of trees are generally separated from the roots, as it were, just above the surface of the earth, but by what means does not altogether appear; though in some instances fire has evidently been the cause. And the roots and the trees thus separated, are assembled together in as much confusion as possible, that is to say, the roots, with all their fibrous parts, lie upon the trees as often as the trees lie upon the roots; in short, they are so confusedly laid together, that nothing less than a vast flood of waters would have produced such an effect of separating them from the earth, and throwing them into such heaps of confusion.

The

The roots and the trees are so generally found as above, that the former have acquired the appellation of crowns.

Though the above trees are supposed to have been thus assembled together, the elevation of the ground cannot be less than one hundred feet above the level of the adjacent rivers.

Some few remains of arts and civilization have also been discovered in the great continent of North-America, which seem to shew that great revolutions have happened in that part of the world, whereby not only the inhabitants thereof, but their respective arts, have been almost totally destroyed; as if no such people, or their arts, had ever existed. For instance:

I have been informed, by the very best authority, that two wells have been discovered walled round with brick, according to the European method.

And likewise that a plough has been found sixty feet deep, by sinking a well for water.

And we have had a recent instance of many coins being found beneath a large stone at Mistick, about four miles from Boston; one of which was lately presented to the Antiquarian Society. The coins are round, and lettered on both sides, but whether in Turkish, Arabian, or Phenician characters, remains to be ascertained; so various are the opinions concerning them.

From the above circumstances it seems reasonable to conclude, that bricks were in use prior to the Europeans settling upon the continent; and that, as bricks were unknown to the native Indians, they must have been applied by a people antecedent to them, with whom arts and civilization had been cultivated to a considerable degree. Whence it is presumed, that those very people, and their arts, have both perished by means of a dreadful revolution in the natural world: of which the plough is another incontestable evidence; for it would be absurd to suppose it was buried sixty feet deep by the hand of man.

The above instances may therefore be considered as marks of art and civilization having made a considerable progress in North-America, at some very remote period of time.

With respect to the coins, we cannot speak of them with equal certainty, as the works of that country, though there is some probability of their being of considerable antiquity.

The great assemblage of bones discovered upon the banks of the river Ohio, have been ascribed, with much reason, to the effects of a deluge of water gradually rising, from which the animals fled for safety into a small spot of ground; but the waters increasing upon them, reduced the larger animals to the necessity of tramp-

trampling down the smaller for their own preservation. But after every possible effort to preserve their own lives, the largest and the most powerful of them perished with the smaller and weaker animals: for the heap of bones as thus circumstanced, the bottom thereof is composed of the smaller, and the upper part of the largest and most powerful animals.

The greatest part of a jaw-bone, belonging to one of the largest of those creatures, containing one of its grinders, or largest teeth, is preserved in the British Museum for the inspection of the curious.

The form of this enormous bone is somewhat analogous to those of the ox or horse; its dimensions as follow, viz. from the top of the condyle to the anterior extremity of the bone in a straight line, thirty-five inches; the base alone in a straight line, twenty-eight inches. A carnivorous animal, longer than the ordinary elephant.

The preceding observations leave little room to doubt the great antiquity of arts and civilization in England, Ireland, and North-America; and at the same time plainly evince that those parts of the world have suffered great devastations from natural causes: therefore to such fatal events, and to the conquests of civilized nations by savage barbarians, we may venture to ascribe the subversion of arts and sciences at sundry periods of time.

Hence

Hence we presume that the preceding deductions may throw some considerable light upon the conjectures of Lord Bacon and other eminent philosophers, relative to the fragments of ancient learning and philosophy, supposed to have been handed down to the Phenicians and Egyptians, from the memorials of more ancient nations, concerning the primitive state of the earth, and from them to the present age.

The concurrence of sacred and profane history in these obtruse subjects, and also with the result of the preceding inquiries, flatters me with the hopes that these reasonings have some foundation in nature and truth.

Therefore, to conclude: if the few observations I have made, or the inferences thence deduced; should prove instrumental in throwing any light upon *ancient history, sacred or profane*; or contribute in any degree to the entertainment of speculative minds, or to the more solid purposes of human life, my labours will be abundantly gratified.

T H E E N D.

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## RECAPITULATION.

RESUMING that a concise account of the preceding work may be acceptable to some of my readers, I have endeavoured to bring the several parts thereof into a nearer point of view, in order to render their relations and dependencies upon each other the more obvious.

The terraqueous globe which we now inhabit was originally in a state of fluidity ; and that, *not owing to any dissolvent principle, or subsequent solution, but to the first assemblage of its component parts.* Whence it is presumed, *that the earth had a beginning, and has not existed from eternity,* as some people have imagined ; although the sagacity of man has not hitherto been able to ascertain, with any tolerable degree of precision, the number of ages elapsed since its component parts were first assembled together by the universal law of gravitation.

We therefore leave the antiquity of the earth to the consideration of future ages, and confine our researches only to unfold its original state and formation, and the changes it has undergone.

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The fluidity of the earth, and the infinite divisibility of matter evidently shew, that the component parts of *air, earth, water, &c.* were uniformly blended together, none being heavier or lighter than another; whereby they composed an uniform mass or pulp, of equal consistence and sameness in every part, from its surface to its center; consequently, the new-formed globe was totally unfit for animal, or vegetable life; and therefore it would seem extremely absurd to suppose, that either the former or the latter were created during the chaotic state of the earth, or prior to its being formed into an habitable world: therefore, the presumption is great, that mankind were not created till the earth was become suitable to the nature of their existence. Whence it appears that the ideas which were so strongly impressed on the minds of the Phenicians and Egyptians, could not possibly have been derived from observation, but from the *laws of gravity, fluidity, and centrifugal force; and more especially since there are no other laws or principles in nature yet known, from whence the chaotic state of the earth could have been deduced.*

May we not therefore conclude, that the Newtonian philosophy, was not only known, but applied to the investigation of physical subjects anterior to the Phenician or Egyptian nations? Since those people have only asserted the result of physical reasonings, and have

either withheld, or were ignorant of the original deductions: the latter being the most probable, we may thence infer, that the doctrines which they advanced, were no other than the scraps of ancient learning, borrowed from the memorials of more ancient nations, and were then become by length of time, nothing more than the prevailing opinion of the ages wherein those people lived. These circumstances being duly considered, seem to indicate many and great revolutions both in the moral and the natural worlds; the latter produced by means of subterraneous convulsions, and the former by the conquests of civilized nations by savage barbarians, many of which events are recorded in sacred and profane history.

May we not therefore conclude, that arts and sciences were arrived to a considerable degree of perfection in very early ages of the world; and that by sundry occurrences they have been repeatedly destroyed and again revived, as if no such people, arts, or sciences, had ever existed.

To return, The component parts of the chaos were heterogeneous, or endued with peculiar *laws of elective attraction*, whereby similar substances are disposed to unite and form select bodies of various denominations, as *air*, *water*, *earth*, &c. by means of these principles,

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the chaos was progressively formed into an habitable world.

But the first operation of nature which presents itself to our consideration, is the oblate spheroidal figure of the earth, acquired from its diurnal rotation, and the laws of gravity, fluidity, and centrifugal force; which was no sooner completed, than the component parts began to act more freely according to their affinities; hence the particles of air united to those of air, those of water to water, and those of earth to earth; and with their union commenced their specific gravities and destroyed that uniform suspension which had hitherto prevailed throughout the whole of the chaotic mass.

Thus commenced the separation of the component parts; for those of the greatest density, began their approach towards the center of gravity; and those of the greatest levity, ascended towards the surface; therefore as the specific gravity of air is nearly 800 times lighter than water, the presumption is great, that the former was sooner freed from the general mass than the latter, and formed a muddy impure atmosphere, surrounding the newly formed globe: water being next in levity, succeeded the air, and universally encompassed the earth in one vast ocean. In process of time these elements became perfectly pure, and fit for animal life.

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The component parts of the chaos being thus *progressively* separated and formed into select bodies, the following consequences necessarily ensued; namely, as the sun and the moon were coeval with the chaos, the solids could not uniformly subside from every part of the surface, and become equally covered by water: for as the separation of the solids and fluids increased, so in like manner the tides increased, and removed the former from place to place without any order or regularity. Hence the sea became unequally deep, and those inequalities daily increasing, in process of time dry land appeared, and divided the waters, which had hitherto prevailed universally over the earth. The Primitive islands being thus formed, in process of time they became firm and dry, and fit for the reception of the animal and vegetable kingdoms.

Such appears to have been the natural order and progression of these things; consequently, as the sun was coeval with the earth, several days and nights preceded the sun's first appearance in the heavens, or its becoming visible on the fourth day, according to the scripture account.

Here it may be convenient to observe, that as the separation of the chaos proceeded from the union of similar particles, and likewise that rest is favourable to such operations of nature, we have thence inferred, that

as the central parts of the earth were more immediately quiescent than those remote from the center, it may be presumed that the former began to consolidate before the latter; therefore it would be repugnant to the laws of nature to suppose, that the central part should consist of water only, and the more superficial part thereof, of a shell or crust, as some writers have imagined.

The atmosphere, sea, and land, being thus formed for the reception of the animal and vegetable kingdoms in successive periods of time, we have now to consider the order in which they were severally created. First, since it appears that the ocean became perfectly pure and fit for animal life before the Primitive islands were formed; therefore we have endeavoured to prove from a series of undeniable facts, that marine animals were first created, and being extremely prolific, they increased and multiplied so exceedingly, as to replenish the sea from pole to pole. The ocean being thus stocked with inhabitants, prior to the formation of the Primitive islands, many of them became enveloped, and buried in the mud by the continual action of the tides; particularly all species of shell fish, which were the least able to defend themselves from such interments. Therefore since the remains of marine animals are imbeded at various depths in the earth, from one to that of several thousands of feet, and this in all parts of the world.

world hitherto explored, they bear sufficient testimony that these marine bodies were thus entombed at successive periods of time, and likewise that they were created prior to the Primitive islands, and consequently prior to any terrestrial animals: therefore, the result of this reasoning is another instance of the agreement between revelation and reason.

It may be needless further to observe, that these beds of marine shells plainly evince that they were generated, lived and died in the very beds wherein they are found, and were not brought from distant regions by a flood, or floods of water, as some people have supposed: consequently such beds were originally the bottom of the ocean. These phenomena therefore evidently corroborate the conclusions we have drawn from Chap. V, VI, and XII. with respect to the ocean prevailing universally over the earth, the formation of the Primitive islands, and the bottom of the ocean being elevated by the expansive force of subterraneous fire, and formed into mountains, continents, &c. whereby the concentric arrangement of the *strata* was totally destroyed and thrown into heaps of ruins. The earth being thus metamorphosed, was productive of great extremes of heat and cold: for it evidently appears from actual observations on the temperature of the air in various parts of the world, that the great extremes of heat and cold, in

in the torrid and frigid zones, are not altogether owing to their respective situations on the globe, but principally to those vast tracks of lands, the continents: therefore, since the extremes of heat and cold commenced with the production of mountains and continents at the time of the deluge, the presumption is great, that the temperature of the air and seasons in the antediluvian world, were so constantly uniform and mild, that frost and snow had no existence on the face of the earth from pole to pole. And this reasoning is abundantly confirmed by the numerous remains of marine animals imbeded in the earth, remote from their native climates; and likewise from the longevity of the antediluvians, which, according to revelation, and reason, suffered little or no alteration from Adam to Noah; the former having lived to the age of 930, and the latter to that of 950. And as a farther testimony of the great change in the constitution of nature, we may instance the first appearance of the rainbow, subsequent, and not prior to the deluge, which was evidently an effect of the same cause.

And we may likewise add, as a corroborating cause thereof, that the period of human life, gradually contracted from the deluge, to the days of Terah, to that of 200 years. And the longevity of Jacob's numerous family seems to shew, that about 120 years was the ordinary

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age of mankind, since his children were the offspring of sundry wives and concubines ; for his son Joseph attained to the age of 110 years, and Levi to 137. See p. 170.

Now, from all the various circumstances relative to the state of nature before and after the flood, we have every reason to conclude, that the antediluvians lived to the amazing age of many hundred years, as recorded in the scriptural account ; and likewise that the spontaneous products of the earth before the flood, were more than sufficient the calls of human nature without art or labour. A time, when the burning heats of summer, and the severities of winters cold, were not come forth ; but spring and autumn reigned together, and the trees were continually loaded with blossom and fruit. Hence no need of any other protection from the inclemency of the seasons, nor of barns for winters store, than the benevolent Author of nature had plentifully provided for them. Consequently in a state of nature like this, there was no temptation to acts of violence, injustice, fraud, &c. every one having plenty and enough, each equally partook of the numerous blessings thus amply provided for him. Power and property being equally diffused, men lived together in perfect peace and harmony, without law, and without fear ; therefore it may be truly said of the antediluvians that they slept away their time in sweet repose on the ever verdant turf. Such apparently was the state of nature

in the first ages of the world, or from the creation to the first convulsion in nature, whereby the world was not only universally deluged, but reduced to a heap of ruins. At that dreadful æra, and not before, the year became divided into summer and winter, spring and autumn, and the spontaneous products of the earth no longer sufficed the calls of human nature without art and labour: wherefore he who sowed would expect to reap, and he who built an hut for his protection, would naturally expect to enjoy the fruits of his own labour: necessity therefore was the parent of property, and property created a thousand imaginary wants, which its possessors endeavoured to gratify, and their example excited similar ideas in those who had it not, but nevertheless studiously endeavoured to gratify their artificial wants by unjustifiable means: hence the necessity of laws, dominion, and subordination, which had no existence in the antediluvian world.

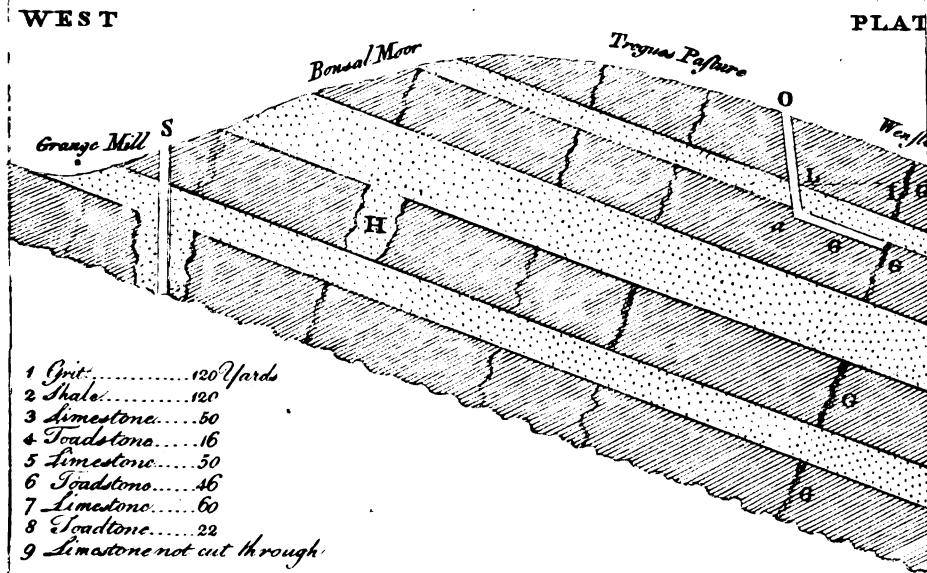
To that great revolution in the natural world, we may therefore ascribe many of the evils incident to mankind; for experience shews, that men who are born in rude and savage climates are naturally of a ferocious disposition; and that a fertile soil, which leaves nothing to wish for, softens their manners, and inclines them to humanity.

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Plotted on the spot directed May 1778.

A Section of the Strata between

Fig. 1.

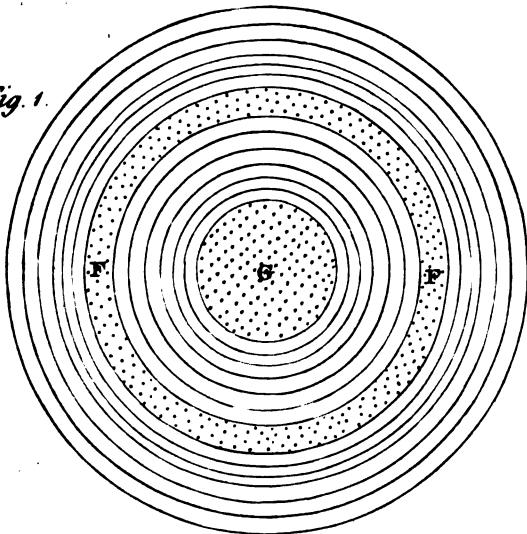


Fig. 2.

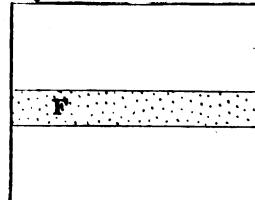
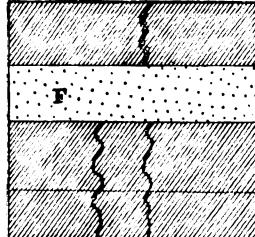


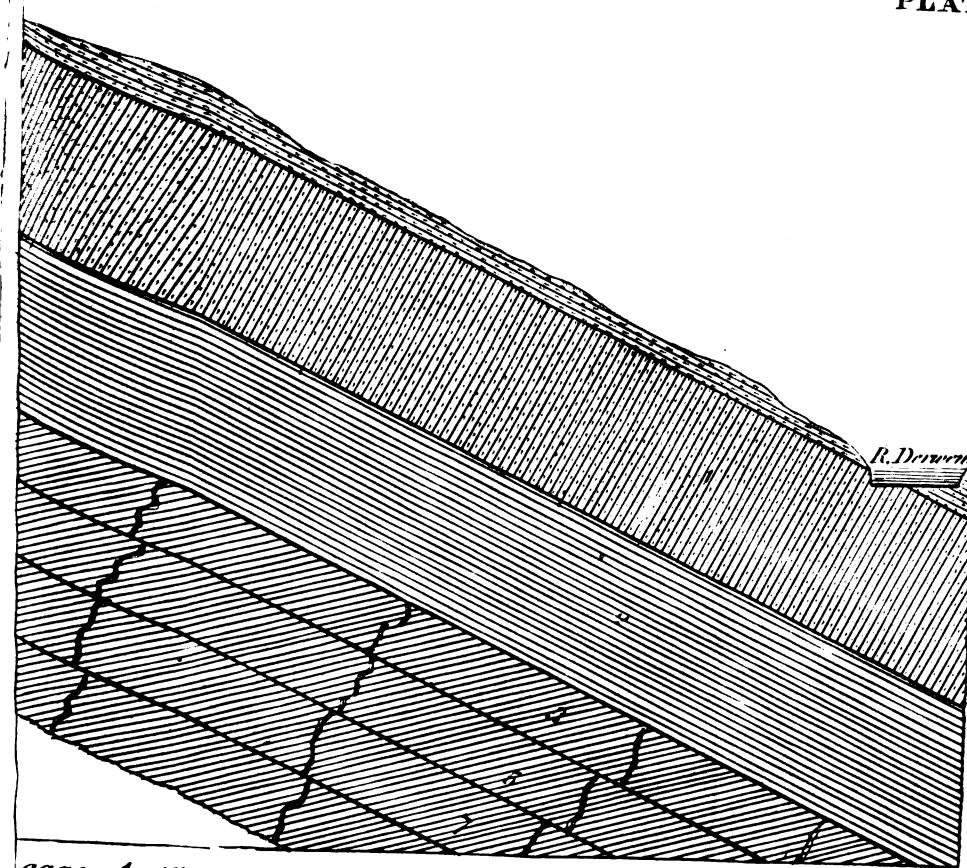
Fig. 3.





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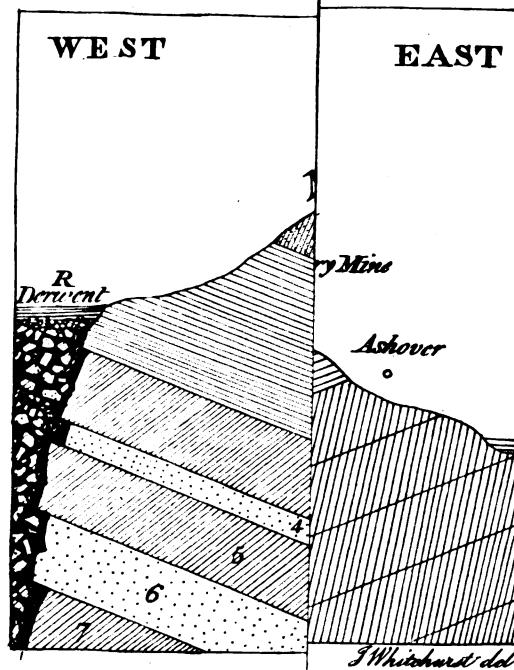
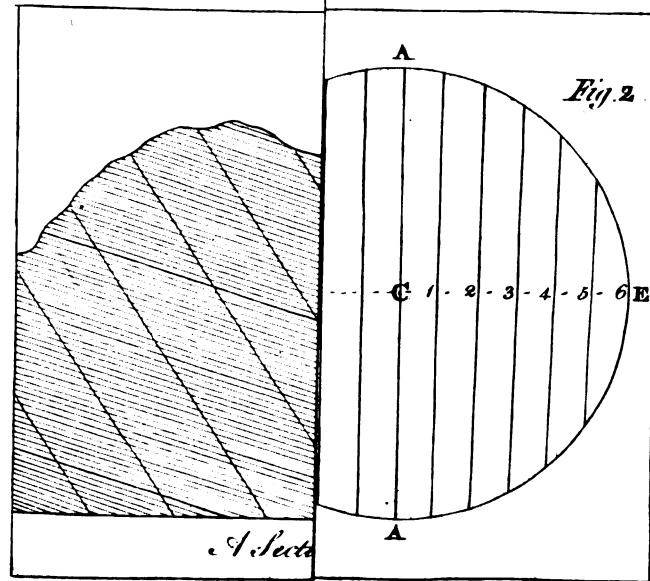
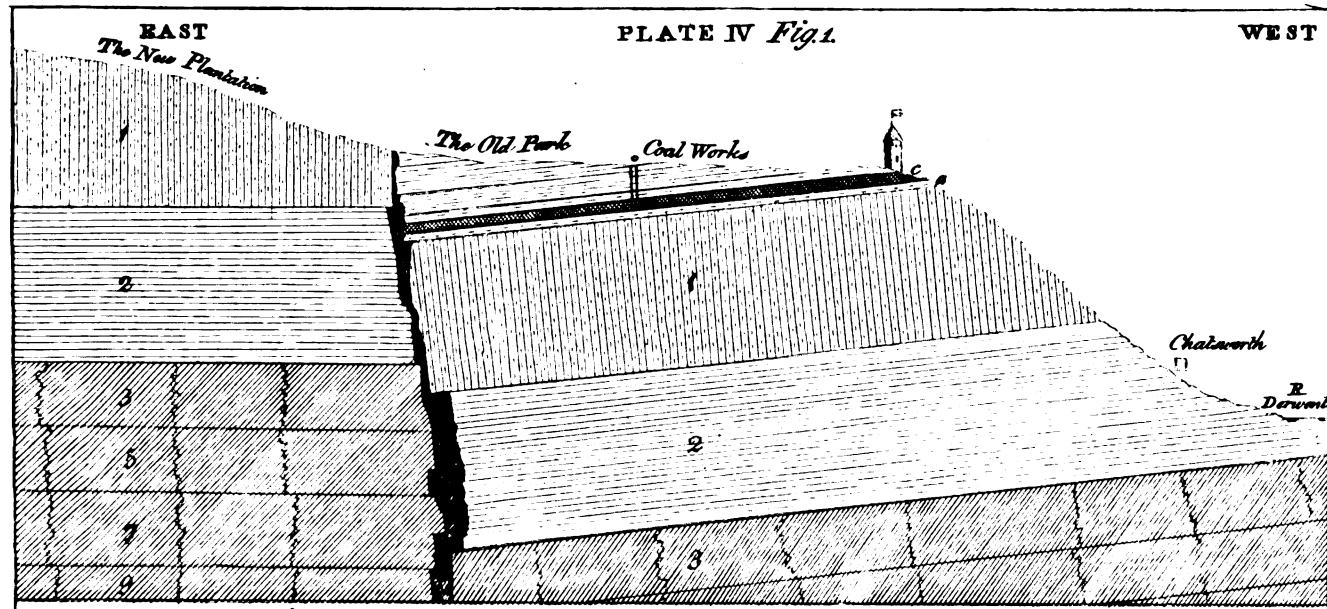




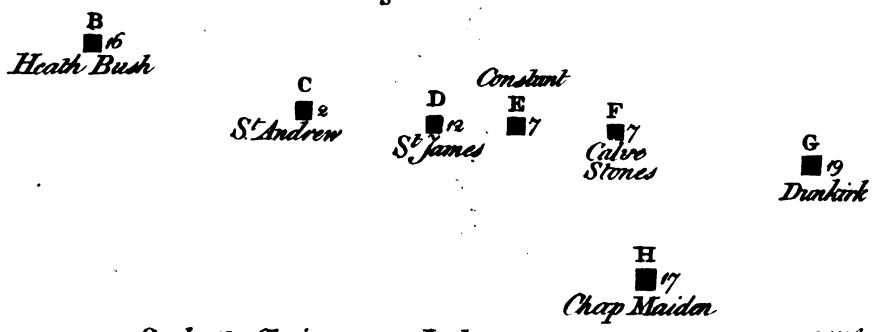
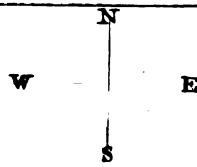
PLATE IV Fig. 1.



A Section of the Strata at Chatsworth, from the Old Park to the River Derwent.

John Whitehurst del.

Fig. 2.



Scale 15 Chains to an Inch.

W. H. Surveyor

A Plan of the Mines on Tideswell Moor.

Fig. 3.

A Section of the Primitive Islands.

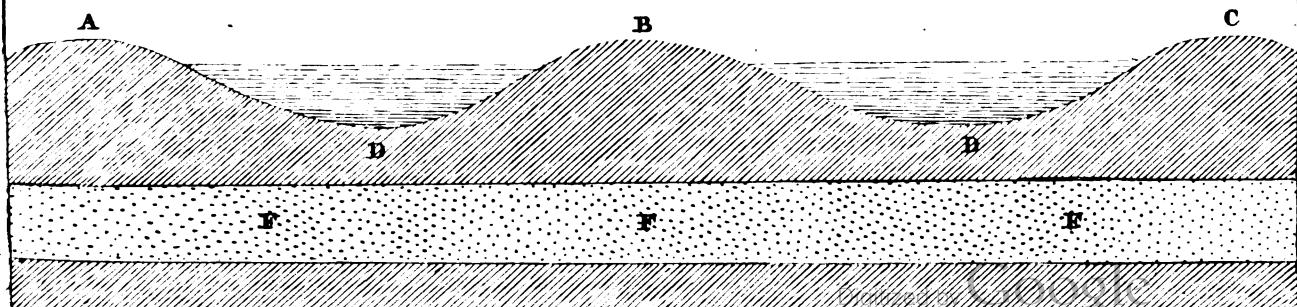




PLATE V.

Fig. 1.

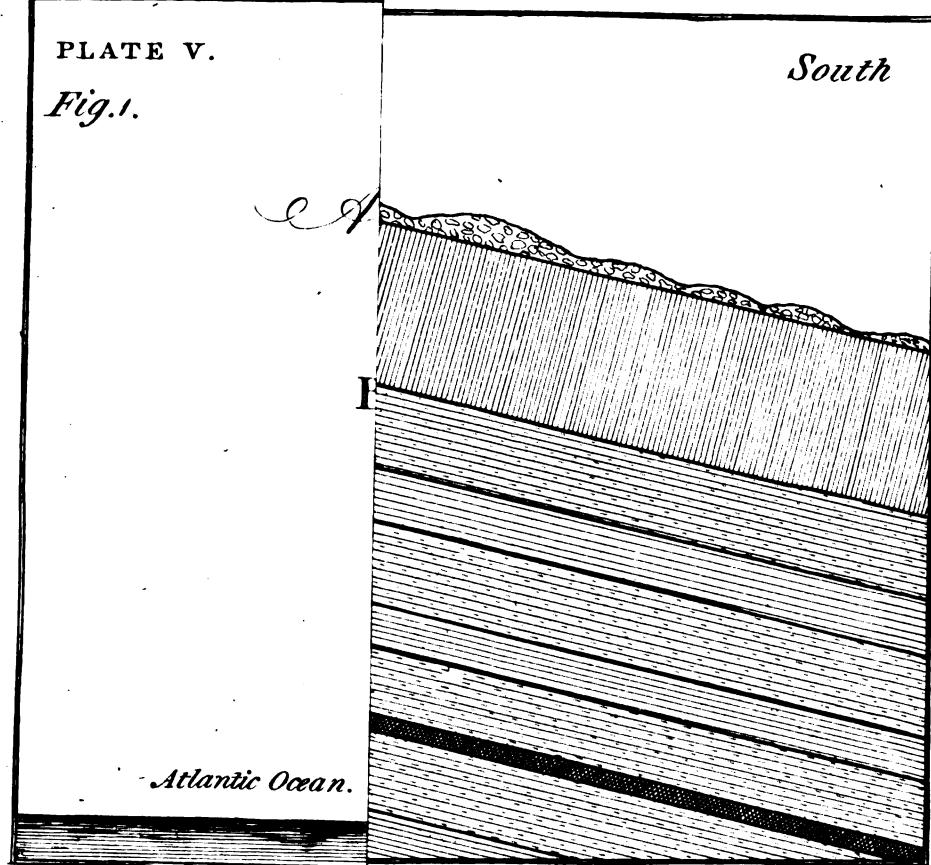
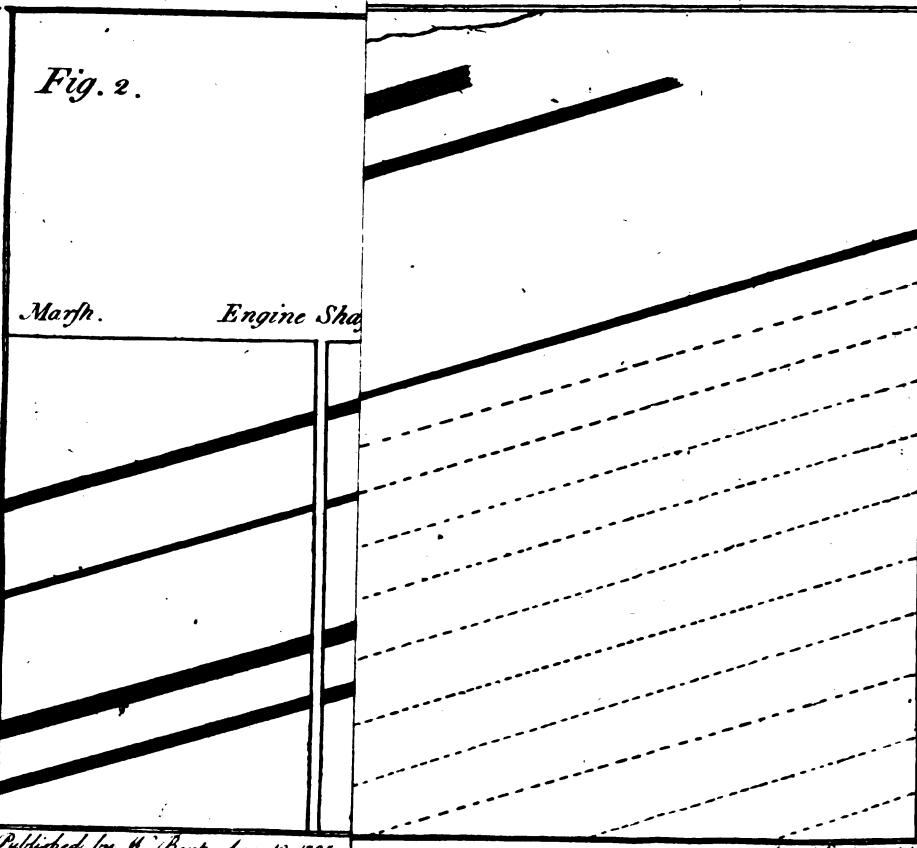


Fig. 2.





*Fig. 1.*



*Fig. 2.*

